SCIENCE

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CONTENTS

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DISEASE RESISTANCE IN PLANTS[1]

THE control of fungous diseases in plants may be effected in three different ways: (1) By killing the parasite before it enters the host, (2) by curing the diseased plants, and (3) by growing disease-resistant varieties of cultivated plants or making the susceptible varieties resistant. So far the first method is the one most generally followed, the means employed depending on the nature of the fungus.

It is easier to protect the host from a fungus which combines a highly developed parasitic character with alternation of hosts than from one which spends its entire life cycle on the same host. For example, when rust (*Rœstelia cancellata*) appears in a pear orchard the danger from it may be done away with by removing all juniper trees from the neighborhood, the juniper being the host for the alternate stage of the fungus (*Gymnosporangium sabinæ*). The same measure may be adopted in the case of red rust of wheat (*Puccinia graminis*) in countries in which the fungus does not reinfect directly the wheat but grows in the spring on the barberry (*Berberis*). This disease has practically disappeared from Germany since the removal of all barberry and mahonia bushes from the vicinity.

The destruction of a fungus living on one host only is more difficult because of the fact that this may necessitate the destruction of all diseased plants or parts of them, an undertaking which could hardly be carried out completely. However, if carried

[1] A lecture delivered by invitation at the universities of California, Wisconsin, Minnesota and Cornell, and the Iowa Agricultural College, in October, 1914.

out thoroughly and before the parasite has reached too advanced a stage of development this method may be crowned with success. A striking example of this is the control of pear blight in the Rogue River Valley, Oregon. In this region the disease has been kept within bounds, while in the Eastern States it was permitted to gain a foothold and is now a calamity.

The spraying of potatoes against *Phytophthora infestans,* by which the fungus is destroyed before it is able to penetrate the tissues of the host, may be included in this class of control measures. Another example is the destruction of the smut spores, which cling to the outer covering of the grain, in the case of stinking smut, for instance.

It is a more difficult task to cure a plant already diseased than to prevent the disease, and only in rare cases is the method of cure known, the reason for this being that plants are not organized like animals, and in most cases it is impossible to influence a central system. The cure of fungus diseases of different trees by giving the roots an abundant water supply is an example of treatment based on the principle that many fungi are unable to grow in tissues which show a high water pressure. In dry soils the water content is kept on a low basis and this favors the attacks of the fungus.

Another example of the curing of the plant is the hot-water method of seed treatment for loose smut of wheat and barley, this treatment being founded on the destruction of the fungus germs within the seed.

We now come to the third method of disease control, that is the use of disease-resistant plants. The importance of this method is well understood by both scientists and growers, but the application of the principle, it must be confessed, is in its infancy.

Utilization of the factor of immunity in disease control may be divided into two parts, that is the breeding of resistant plants and the artificial immunization of plants. From a scientific point of view, however, both of these rest on the same basis.

Before a disease-resistant race can be bred resistant individual plants must be found. It is a well-known fact that in the vegetable kingdom closely related species suffer in different degrees from attacks of the same parasite. The difference in resistance of the various species of one of our most important cultivated crops, wheat, is unusually prominent, as shown by the researches of Wawelow. Of the eight botanical species which are generally thought to have produced the cultural varieties of our wheat, *Triticum vulgare, T. compactum* and *T. spelta* are attacked by red rust; *T. durum, T. polonicum, T. turgidum* and *T. monococcum* are resistant; the western European varieties of *T. dicoccum* are resistant, and the eastern varieties of Turkestan are liable to rust. *T. dicoccum dicoccoides,* which was found in Palestine some years ago and which has sometimes been regarded as the ancestor of our common cultivated wheat, *T. sativum,* is also a non-resistant species.

The varying susceptibility of species of the same genus makes it possible to substitute for highly susceptible species others of nearly equal cultural value which are less susceptible or resistant. In the case of the coffee plant very good results have been obtained by this means. It is well known that *Coffea arabica* was completely destroyed throughout the Asiatic tropics by the rust fungus *Hemileia vastatrix.* The related African species *C. liberica* appeared to be resistant to the disease and was brought under cultivation in the entire territory in which *C. arabica* had been grown and in

which coffee culture was possible. The immunity of this variety, however, proved to be of an unstable nature, and as a consequence the growers were obliged to import *C. robusta,* a species having lower commercial value, from the virgin forests of Africa. Because of the fact that *C. liberica* produces beans of much poorer quality than *C. arabica* and *C. robusta* beans of a poorer quality than *C. liberica* their substitution was of restricted value, but it saved the valuable coffee industry in some regions from ruin.

The maintenance of profits with the inferior coffee is made easier by the degeneration of taste among civilized people—the result of standardization in all branches of life. The average man to-day lacks the faculty of determining whether his beef was cut from a Holstein or a Hereford, whether the fowl on his table was fed with barley or oats, whether a wine is natural or sugared, or whether the coffee he drinks is *C. arabica, C. liberica* or *C. robusta.*

Even though the value of the resistant plant is lower, as in the case of the examples cited, the possibility of improving the variety still remains. Two methods may be used toward this end, that is grafting a non-resistant on a resistant variety or crossing the two. The first was followed in dealing with *Phylloxera* of the vine in Europe. The European vineyardists grafted their own highly cultivated varieties on the roots of the American vine, which latter resists the attacks of the parasite, and in this way produced a vine combining the requisite wine-producing qualities of the European vine with the disease resistance of the American vine. In view of these facts it would seem easier to replace the European vine with the American, but this is not practicable, because under European conditions of climate it is not possible to prepare wine from American species. The grafted vine is only an imperfect substitute, because its life is of short duration and the labor of grafting makes its culture expensive.

As the grafted vines are heavy bearers, the disadvantages from their use are not felt as keenly in France, where the aim of the viticulturist is to produce large quantities of wine, as in Germany, which aims to produce "quality wines." The really first-class wines are produced from vines which are permitted to grow only a few grapes, and this, coupled with the fact that the quality of wine improves with the age of the vine, shows that the cultivation of grafted vines is more impracticable in Germany than in France.

Another method of improving disease-resistant wild species and preparing them for cultivation is illustrated in the case of sugar cane. In the eastern part of Asia this plant, especially the high sugar-producing varieties, is subject to the so-called sereh disease, the nature of which is still unknown. In British India, however, the wild resistant Chunee cane was found, but it had too much fibrous substance to be suitable for sugar-producing purposes. Several hundred crosses were made between it, on the one hand, and the Cheribon, on the other. As a result of this crossing, several hybrids were obtained which produce the maximum amount of sugar and are at the same time resistant to the disease. As sugar cane is propagated by using its vegetative parts, that is parts of the stem, these qualities can be readily preserved. Notwithstanding these favorable results, however, our experience with sugar cane has proved that its "immunity" is not permanent, but diminishes in the course of cultivation, and the same is true in the case of the two varieties of coffee mentioned, the disappearance of immunity in

these being relatively rapid. No guarantee of future disease resistance has been found in either the hybrids or in the wild species.

Not only do closely related species show a difference in susceptibility to disease, but varieties and races of the same species behave differently in this respect. An example of this is *Triticum dicoccum*, one variety of which, as already stated, is resistant to rust and the other non-resistant. Additional examples are *T. vulgare*, a few varieties of which are resistant; certain varieties of potatoes with reference to *Phytophthora infestans; Pinus sylvestris* with reference to *Lophodermium pinastri;* and other cultivated plants. This difference in disease-resistance between races of the same species is of far greater importance than the difference between two species, because generally there is greater similarity between the cultural value of the two races.

The occurrence of healthy plants among diseased ones is not absolute proof of the resistance of such plants, and therefore to make sure of the immunity of any special strain careful experiments are necessary. It is not enough to raise a number of plants of an apparently resistant strain in a certain place. The question of resistance should be investigated from the beginning on the broadest basis. One of the principal things necessary is to expose the resistant plants to the fungus causing the disease to which they appear to be resistant. In the case of fungi which live in the soil, such, for instance, as the fungus causing stinking smut, the first requisite is to determine whether they are present and, if not present, to introduce them, while in the case of fungi spread by the wind, such as those causing rust and mildew, the infection should be induced either naturally or artificially.

The presence of the fungus, however, is only one factor in the experiment. The second factor is the disposition of the host plant, that is, its internal qualities, which makes infection possible. The third factor is the coincidence of the infection period with the susceptible condition of the host. When all of these factors are present the possibility of infection is certain, and only under such circumstances will the results be reliable.

Fluctuation in the prevalence of fungous plant diseases is due to the presence or absence of proper conditions for the development of the fungi causing them. For instance, loose smut appears to a very serious extent in certain summers, and naturally it would be expected to be still more prevalent the succeeding summer. The fact is, however, that although spores in sufficient quantity to infect all the flowers in the field were scattered, the disease may be much less serious, the reason being that the plant was not in the proper stage a sufficient length of time to receive the infection, or in other words the weather conditions caused too rapid withering of the flowers to permit infection.

The effect of different conditions on the relation of host and parasite makes it necessary that investigations to determine the resistance of strains shall be carried on not only for a number of years, but also in different localities. Even under such circumstances the outcome may be uncertain. In many cases immune forms when cultivated prove to be only partly immune.

The best opportunity for finding immune strains is afforded by diseases which are of regular occurrence. In such cases it is possible to find with a degree of certainty forms which are immune in a certain locality, but while such experiments may give results of practical value, the

problem of immunity can not be solved in this way.

The third way to obtain immune forms is to select resistant individuals and from them breed pure strains. In the case of many diseases, although certainly not in all, healthy individual plants are found in the diseased plots, and the breeding of immune strains from these individuals would seem to be very simple, but experience has taught the contrary. All the factors pointed out in connection with the selection of immune forms must be reckoned with, but in a still greater degree. So long as the appearance of the disease is the only criterion by which to determine the susceptibility of the plants to disease the experimenter is exposed to all kinds of unknown influences.

Several attempts to breed kinds of wheat immune to stinking smut have been made without any real results. The question of producing such kinds is of great importance, especially for the United States. In the large wheat areas of Idaho and eastern Washington, for instance, stinking smut is very serious, not infrequently causing a loss of twenty-five per cent. of the crop. Inspection of seed in that state discloses the fact that a large part of it is covered with the smut spores, and treatment of the seed with copper sulphate is said to be useless because the soil is so badly infected. In many European countries, however, smut has been completely controlled.

In the case of smut the possibility of infection, as far as the fungus is concerned, is very great. As infected plants are in general not very productive on account of the seed being destroyed by the fungus, it might be supposed that smut-resistant plants would propagate well and that the strains would become immune. This, however, is not the case, and it shows that the breeding of smutless wheat by selection of healthy individuals has little chance of success, a fact which has been proved by experiments already made. That this is an impossibility, however, can hardly be stated definitely, but success could be obtained, if at all, only after tremendous amount of labor in breeding and trying hundreds of forms or by fortunate accident.

It will be remembered that Orton by this method of breeding succeeded in obtaining varieties of cotton and watermelon resistant to *Fusarium* wilt. As the original resistant individuals found in the field gave too small yields, he crossed them with prolific varieties and in this way combined the disease resistance of the one parent with the productivity of the other. A similar thing was done by Bolley with flax and by L. R. Jones with cabbage, both of whom bred wilt-resistant varieties by selection. In the case of wheat, it is the opinion of the writer that there would be better chance of breeding smut-resistant varieties if strains rather than individual plants were selected and crossed with productive varieties. Orton very successfully selected a certain variety of cowpea resistant to wilt disease and root knot, that is, the iron cowpea grown in South Carolina, and crossed it with a more desirable variety. By this means also, that is by selecting certain varieties, some of the *Phytophthora*-resistant varieties of potatoes were obtained, and probably also the square head wheat which shows immunity to *Puccinia triticina*.

Next to field experiments, those in the laboratory might aid in the discovery of resistant varieties of cultivated plants. Such experiments have advantages over those in the field and are practical in case of diseases caused by parasites that may be grown artificially in pure cultures.

The greatest advantage of the laboratory experiments is that in them the experimental plants may be infected at any time and under any conditions. The plants may be kept dry or wet and under different temperatures, they may be fed in different ways, and the factors of growth may be influenced within wide limits. Under such conditions the optimum of infection may be determined for different varieties.

The results of laboratory experiments frequently differ greatly from those of field experiments. For instance, in Wawelow's field experiments *Triticum durum*, *T. polonicum* and *T. turgidum* were resistant to *Erysiphe graminis*, but in his greenhouse experiments they became infected with this disease. Reed's experience in this respect was similar to that of Wawelow. It is the opinion of the writer that the host plants were strongly influenced by circumstances, but Wawelow attributes the different results to favorable conditions in the greenhouse for the development of large quantities of conidia.

Such unbalancing of the host is not infrequent and in the natural environment is due to extreme weather conditions. Some species of *Ribes* are known to be immune to the æcidium of the pine blister rust (*Peridermium strobi*), but these species may be infected and form æcidia under a bell jar. In the field the leaves are infected, this being shown by the development of slight yellow patches, but the æcidia never appear. The same is true in the case of some varieties of wheat with regard to *Puccinia*, according to Fraser, on account of the thickness of the cuticle. This partial immunity is satisfactory for practical purposes, and while partially immune plants suffer in a small degree through reduction of the assimilating surface, they do not increase the danger of spreading the rust, as they form no new sources of infection.

Although some very profitable results have been obtained, as already shown, from the immunity methods discussed, the problem of immunity should be solved in a different way. Immunity must not be regarded as the only definite point to be studied. In the case of every special disease efforts should be made to determine the causes of resistance. That immunity from different diseases is due to different causes is clear and the factors which determine this must now be sought.

The cause of immunity of wheat and barley from loose smut is among the simplest. From the investigations of Hecke and Brefeld it is known that the smut spores are carried by the wind to the stigma and that there they germinate and find their way to the ovule through the pollen tubes. As is generally known, there are varieties of wheat which have closed flowers, which means that fertilization takes place within the glumes. In such cases the smut spores can not reach the stigmas at the proper time, and therefore infection can not take place. In this case, therefore, by investigating the question of flowering the problem of resistance can be solved without artificial infection. Many of the intermediate stages which exist between immune and susceptible races may be detected by close observation. In like manner several races of rye show different degrees of susceptibility to ergot (*Claviceps purpurea*), the resistance being least in those having a long flowering period.

The channel from the calyx to the carpels is open in many varieties of pears. Such varieties are susceptible to infection by *Fusarium putrefaciens*, as Osterwalder has shown. The varieties without the open

channel are protected against this means of infection.

The habitus of a plant may influence its disease resistance. An instance of this is the potato with reference to the late blight (*Phytophthora infestans*). Infection of the potato vine with this disease is caused by the conidia being carried to the leaves by the wind. The conidia remain on the leaves until a drop of water causes them to liberate their zoospores. These swim around in the water for some time, then drop their cilia, germinate, and send a hypha into a stoma. Passing through a potato field shortly after a heavy rain, it will be observed that the leaves of some sorts dry within half an hour, while others remain wet for several hours. Generally the quick-drying varieties are less susceptible to the disease than the slow-drying varieties. Slow drying is the result of the plant's habit of growth, which hinders the evaporation of the rain drops. Such plants have flat leaves. Small, hairy leaves, as well as an airy, open growth of the whole plant, facilitate drying. It is possible that the arrangement of the stomata also may exert an influence on the attack of the fungus.

In the case of the grape leaf the arrangement of the stomata is of great importance. For a long time it was not known why spraying with Bordeaux mixture did not, in all cases, prevent the attack of *Peronospora*. Finally, however, Ruhland and Müller-Thurgau explained this by showing that in the grape leaf the stomata are formed only on the under surface. Spraying of the grape, therefore, can be effective only when the spray mixture reaches the under surface of the leaves, and this fact must be borne in mind when dealing with fungi which enter the leaf through the stomata. A similar thing was observed by the writer's assistant, Dr. Pietsch, whose investigations have not yet been published. He found that the resistance of some Remontant carnations is due to the form of the stomata, which makes it impossible for the hyphae to penetrate them. In some cases, however, the hyphæ can not produce infection even though they penetrate the stomata. In the case of cereals immunity from rust is independent of the stomata.

In cruciferous plants the water pores are the avenues of entrance for many bacterial diseases. The relation between their form and disease resistance, however, has not yet been established.

As may be seen in the case of the potato, the lenticels as well as the stomata may influence immunity. The scab fungus (*Oospora scabies*) after penetrating into the outer layers of the potato establishes itself in the lenticels and causes the surrounding tissues to produce an abnormal corky growth. Bacteria also may enter the lenticels, especially when on account of moist conditions the tissues are forming callus. This callus, however, does not form a sufficient protection, and softened tissue and even decaying spots result.

The lenticels are developed very differently in different varieties of potatoes, and it is therefore important that the relations between them and resistance to scab and bacterial rot be investigated.

The condition of the cuticle may influence infection, as shown by the behavior of cereal seedlings in resisting smut diseases. Such influence, however, is possible only in the very early stages of the seedlings' growth, that is before the tissues have attained full development. Since the germination tubes of smut are able to dissolve cellulose, there must be stored substances which cause resistance, and in this connection silicic acid is probably the first to suggest itself. Indeed the quantity of

this substance is different in seedlings of different kinds. Sorauer found resistance of different carnations to be due to thickness of the cuticle. It might be caused also by the wax layer, which is present in *Gramineа*, carnations, and other plants.

In his experience the writer found that the wax layer influences the attack of *Coniothyrium* on raspberries. In a large horticultural establishment varieties which were covered by a thick blue wax layer were free from this disease, while other varieties were completely killed. The wax layer may exert its influence in different ways, that is it may prevent direct penetration by the hyphæ or it may act indirectly by causing the moisture to run off the plant. This was observed by the writer in making sprayings with Bordeaux mixture. In the case of plants covered with the wax layer the mixture ran off quickly and left no moisture. Conflicting results have been obtained from observations of *Glœosporium venetum* on raspberries on the fruit farm of the University of Minnesota. There is no difference between raspberries with wax and without wax. *Glœosporium venetum*, however, has very sticky conidia and is held by the wax layer, while *Coniothyrium* spores are washed away.

The hairs on the surface also play a part in this connection. Their unfavorable influence in the case of potato late blight has already been mentioned. A very interesting case of hair-like structures is found in the pea family. In some varieties the seeds are imbedded in a woolly outgrowth of the inner epidermis of the pod. Frequently when pods are infected with *Ascochyta pisi* the fungus penetrates into the interior. In varieties without these hairs the seeds are infected only when they are directly in contact with an infected spot of the pod. But when the interior is covered with the woolly outgrowth the fungus grows as in a culture medium and infects every seed.

The cork, which is without doubt a protecting tissue, is a definite kind of epidermis. The writer has never seen branches of cork elms attacked by fungi, but the common elm is subject to the attacks of several species. In the case of the potato the cork layer has the greatest significance.

The causes of the protecting action of the cork, however, may be different. Certain fungi are able to penetrate this cork layer, such as *Phytophthora*, and probably *Fusarium* and *Spondylocadium*. But the last-named fungus is able to penetrate only the very outermost layers of the potato, where it forms mycelium and sclerotia normally. Whenever it grows into the tissues below it must use the channels already opened by other fungi which may happen to be present. Thick cork layers seem to be impenetrable for *Phytophthora* and *Fusarium*. The questions involved are very difficult to solve, because it is hardly possible to judge whether a cork layer is intact or not.

As small wounds occur very generally, the rapidity with which wound cork is formed is possibly of more importance than the absolute thickness of the cork layer. In the course of work with black leg of the potato the writer was able to study this question. It is easy to cure a bacterial infection artificially. The potato is able to close a wound within a short time by the formation of cork. When the growth of bacteria is diminished by low temperature or drought the potato closes wounds more rapidly than the bacteria can penetrate. The ability to form wound cork varies in different varieties of potatoes. Some varieties begin cork formation within six hours after the wound is

inflicted, while in other varieties it is not begun for forty-eight hours or more. From this it is clear that the former may withstand infection better than the latter. By means of these experiments the relation between the structure of the plant and its bacterial resistance has been established beyond doubt. A similar relation, however, does not exist in the case of fungous diseases, as the fungi may penetrate the newly formed cork.

All the instances cited illustrate the influence of mechanical means of protection. But the plant also often escapes disease by means of rapid growth. A microscopic examination of seedlings attacked by smut shows that a number of seedlings may be infected, and yet only a few of the plants will show the disease, proving that the infection has been suppressed in many cases. In this connection attention is called to the fact that in the case of both stinking and loose smut the infection originates in the seed. The fungus mycelium grows in the seedling, but by rapid growth the latter may outstrip the fungus, which remains in the base of the plant and is harmless.

There are still other factors in plants which may influence resistance but which are not perceptible through the microscope. They may be found by physical or chemical research because they are based on the difference of contents. Probably these factors are of far greater importance than those already discussed. But till now these questions are far from being treated in an adequate manner. The foremost reason for this may be that here we have to deal with chemical substances such as albumens, tannins, etc., and there are few botanists who possess the necessary chemical knowledge to undertake such experiments. A bridge, therefore, must be built between botanists and chemists, and the latter's interest in this question awakened.

One of the best investigations made in this direction up to this time is that of Münch on the immunity and susceptibility of trees. He has shown that susceptibility of woody plants to fungous diseases depends on the quantity of water and consequently on the quantity of air in the wood. This is in accordance with the writer's experiments with *Rhizoctonia* and *Fusarium* which have shown that these fungi also have a high air requirement. In the United States, with its large areas of irrigated land, this fact is of great importance. It is possible that the influence of both of these fungi may be diminished by thorough regulation of water conditions.

A glance at sugars and acids shows that these substances also exert an influence in disease resistance. The presence of benzoic acid in *Vaccinium vitisidæa* is supposed to be the cause of its resistance to fungous diseases. In the same way the tannins have a relation to resistance. This was shown by Behrens in his work on fruit decay and confirmed by Cook and Taubenhaus. On the other hand, sugar favors the growth of fungi, as is shown clearly in the case of apples and pears. Henneberg even claims immunity for some varieties of potato from certain diseases on account of their high sugar content, but this has not been established beyond doubt.

Finally the enzymes exert a definite influence on immunity, the oxydases taking the lead. These ferments work directly or indirectly by producing resistant chemical substances.

This paper, it is believed, gives sufficient idea as to how, in the opinion of the writer, the problem of disease resistance should be dealt with in the future. The present methods should by no means be abandoned, for practical experience and happy accidents may help a great deal, but in addition to carrying out these methods an ef-

fort must be made to establish scientific fundamentals for new investigations. Efforts must be made to find the causes of immunity, and after solving this question to determine without infection the disease-resistant qualities in different varieties and individuals in order to be able to establish the desired resistance and at the same time eliminate undesirable qualities. It is only by working along this line that the breeding of disease-resistant varieties on a scientific basis can be accomplished and results which lie within the limits of possibility obtained.

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THE CAVERN OF THE THREE BROTHERS (ARIEGE)

For the third time in less than three years it has been the good fortune of Count Begouen of Toulouse to announce the discovery of important works of art left by paleolithic man on the walls and floor of Pyrenean caverns. His two previous discoveries were noted at the time in the columns of Science.[1]

Quaternary art objects may be classed under two heads: the portable and the stationary. The portable class includes in part carved tools, weapons and ceremonial objects, such as poniards, spear throwers, bâtons, etc. It also includes engraved pebbles as well as carved fragments of stone, bone, ivory and the horn of stag and reindeer; in fact, almost anything that could be seized upon to satisfy the exuberant demands of the cave man's artistic impulse.

Stationary art embellishes the walls and ceilings of caverns and rock shelters. In rare instances the fine clay of the cavern floor was utilized for sketching and modeling purposes. The scientific world has been more or less familiar with the portable class of troglodyte art for more than half a century. Our acquaintance with the stationary art is of more recent date. The first discovery of this kind was made by Sautuola in 1879 at the cavern of Altamira in northern Spain. The scientific world, however, did not grasp the real significance of Sautuola's discovery until, after the lapse of nearly twenty years, similar finds had been made in France.

All three of Count Begouen's discoveries have to do principally with cave art of the stationary kind. In July, 1912, near his country estate of "Les Espas," which is only a short distance from Saint-Girons (Ariège), he found a series of subterranean galleries and connecting corridors opening out of an underground stream bed. On the walls of one of the corridors were several engravings of the horse, reindeer, mammoth, etc. Five days later it was the privilege of the writer to see this prehistoric gallery, called Tuc d'Audoubert, in company with Count Begouen and his three sons.

In October of the same year Count Begouen and his sons succeeded in gaining entrance to an additional gallery of the series, but not until after they had broken down two stalagmite pillars that blocked the narrow passage way. What they found there has already been described. The most notable objects were two figures of the bison modeled in the clay of the cavern floor. They owed their preservation to the accidental sealing up of the gallery ages ago by the stalagmite pillars. In view of their excellence, it is probable that they are not unique examples; that perhaps other similar figures less fortunately situated have been destroyed because the artist did not know how to temper and fire his product.

The need of something less difficult to manipulate than stone, bone, ivory and horn must have been ever present in the experience of the troglodyte artist; it is not strange therefore that he should have finally hit upon clay. This illustrates how near an individual or a race may come to some great discovery and yet fall short of it. Thus was the discovery of the ceramic art left to the later more practical, if less artistic, neolithic races.

The latest discovery of Count Begouen and

[1] N. S., XXXVI., pp. 269 and 796, 1912.

his sons, announced recently in a note read at the French Institute, the substance of which is contained in a letter just received from him, was made only a few days before the declaration of war last August. In fact, it was on July 20, 1914, exactly two years after the discovery of Tuc d'Audoubert, that he and his three sons descended by an opening until then unknown into a superb cavern, which in their honor he has named *Caverne des Trois Frères.* It is about half way between Tuc d'Audoubert and the cave of Anlène, in other words about a quarter of a mile from each. Count Begouen believes that the three caverns are connected by corridors; proofs of a conection between two are already in hand.

The exploration was not only difficult, but also dangerous (there are galleries into which he has not yet been able to penetrate), but one is well paid for the effort because of the beauty and elevation of the ceilings as well as "the numerous prehistoric remains encountered there." On the floor were many bones, flint implements and objects bearing man's handiwork.

The results of their first visits were of such a nature as to foretell an abundant harvest when the work shall have been resumed. Upon a bone fragment there was an excellent engraving of a fish. But the chief display of art was on the walls, especially of the terminal gallery, where more than two hundred admirably engraved figures of animals are to be seen. The following species have already been identified: Mammoth, rhinoceros (the first found in the caverns of the Pyrenees), bear, lion, wolf, deer, reindeer, wild goat, horse, bison, chamois, eel and bird. There are also anthropomorphic figures including a curious female type drawn in black; it seems to be walking almost on all fours with the head surmounted by a reindeer horn. It might represent a human figure wearing a mask, or perhaps a figure with mixed attributes; if the latter, then we have a new note in paleolithic art, for until now that art has revealed no representations of mythologic creatures.

Most of the mural art in the *Caverne des Trois Frères* is admirably done; a small panel with reindeer at rest evidently enjoying themselves is "like a page from an album." From the viewpoint of the engravings this cavern is "certainly the richest and the most beautiful thus far known." In addition to the animal and anthropomorphic figures, Count Begouen noted lines, spots of red or black, and red claviform signs, presumably representing clubs.

War was declared before excavations could be begun. With two of the "trois frères" at the front since then and the youngest having recently joined them there, it can readily be understood why Count Begouen does not wish to return to the cavern so aptly named until he can do so accompanied by his three boys after the war is over. Let us hope that he may have to wait neither long nor in vain.

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SOME EARTHQUAKE PHENOMENA NOTED IN PANAMA

IN October, 1913, the writer was asked by President Porras of Panama to undertake some investigation into the causes of the earthquakes which, during that month, were felt almost daily in the Azuero peninsula which forms the south central part of the republic.

In the course of this investigation two well-recognized geological principles took on a new and impressive significance for the writer, and a vividness that he had never before been able to clothe them with. These principles are the relation of faulting and fracture to earthquakes, and the elasticity of the earth as expressed in earth-waves.

Simultaneously with the first and heaviest shock the cable line from Panama up the west coast to California broke at a point where it passes over the submarine escarpment from the continental shelf at about 60 fathoms to the ocean depths at from 700 to 1,000 fathoms. The distance on the chart from the 60-fathom sounding to the 784-fathom sounding is less than two miles. It is not known, however, whether the slope between these two points is

uniform or locally abrupt. Not only did the cable break, but the repair boat reported that half a mile of it had been buried in debris on the bottom and had to be abandoned and a new piece spliced in.

It is said that the cable was broken in almost the same place by an earthquake between the years 1882 and 1883.

To the writer the only adequate explanation of the breaking of the cable and the burying of half a mile of it is that movement occurred along an old fault escarpment, or fault zone, which marks the boundary between the continental shelf and the deep ocean basin, and that this movement was great enough to cause the earthquake, resulting in a submarine landslide. It is not known whether the fault displacement broke the cable or whether the submarine landslide caused by the jar of the faulting broke it; of course the jar of the fault movement was the earthquake.

Nearly all of the later shocks felt were accompanied by peculiar underground sounds which, at times, seemed to begin to the eastward of the observer and to die away in 5 or 10 seconds to the westward of him. The sound was not unlike the dull boom made by the fracture of ice on large lakes, due to shrinkage, when the weather has suddenly become extremely cold. The noise of these ice fractures may begin far to the right of an observer and die away in the distance, in a few seconds, to the left of him. After listening, several times, to the underground sounds that accompanied shocks, the writer became convinced that they were due to the formation of small shears or strain-relieving cracks in the rocks, formed perhaps considerably below the surface. A search for such cracks was unsuccessful, due either to the sparsity of rock exposures or to the fact that cracks might not be distinguishable from ordinary jointing, or that they might be parallel, or nearly parallel, to the surface and might not outcrop in the vicinity at all. It is thought that the rock strains would be relieved by many very small fractures along a strained zone rather than by one large break, and the differential movement along each small fracture might be extremely small, possibly measurable say in tenths of an inch.

The breaking of the cable and the burying of a part of it, together with the underground sounds heard several times, as far as the writer can see admit of no other adequate explanation than that herein ascribed to them.

The other geological principle connected with these earthquakes was that of the elasticity of the earth's crust. The writer was on the top of a steep conical mountain peak which stood about 2,000 feet above the surrounding country, when a heavy quake came, causing the mountain to behave like a stiff jelly. One felt as though the mountain were swaying through an arc of several inches. Making ample deductions for the tendency of the senses to exaggerate such an unusual phenomena, it is thought that the swaying motion in a horizontal plane was actually about three quarters of an inch. It was one of the most impressive demonstrations of the elasticity of solid rock, of the somewhat jelly-like motion that can be imparted to a "rock-ribbed" mountain, that one could well imagine. With the motion a dull, heavy underground rending sound began on the northeasterly to northerly side of the mountain and died away in the distance on the other side, being audible for say 20 to 25 seconds.

These underground sounds had a most terrifying effect on the inhabitants, who believed they were about to be overwhelmed by some volcanic catastrophe. The investigation was very successful in assuring them that these dreaded sounds were quite harmless and were not due to any subterranean fires, and that the near-by mountains were not going to turn into volcanoes and overwhelm them as they feared. In spite of this soothing information, however, a few of the natives were unjust enough to criticize the writer for not stopping the quakes as quickly as they wished. Such is "man's inhumanity to man."

Donald F. MacDonald
U. S. Geological Survey

THE THOMAS SAY FOUNDATION

An organization, with the above name, was formed under the auspices of the Entomolog-

ical Society of America at its Philadelphia meeting. Its purpose is to honor the memory of the father of American entomology, Thomas Say, by the publication of a series of volumes on systematic entomology. These volumes are to be of a monographic or bibliographic character and to deal only with the insects of North America. It is hoped that a series of volumes similar in appearance and of the same high standard as the volumes of the John Ray Society of England can be issued. To this end a temporary committee consisting of J. M. Aldrich and Nathan Banks, U. S. Bureau of Entomology, E. P. Van Duze, University of California, Morgan Hebard, Academy of Natural Sciences of Philadelphia, treasurer, and Alex. D. MacGillivray, University of Illinois, editor, was appointed to solicit funds, and when these are sufficient, to issue such works as they may deem worthy of publication. The most difficult problem confronting the committee is the securing of a fund sufficient for publication. It is hoped that an endowment fund, the income from which will be sufficient for the issuance of about two volumes per year, will eventually be available. Until such a time, however, an attempt will be made to obtain subscriptions for the issuance of volumes.

AWARDS OF THE FRANKLIN MEDAL

THE Franklin medal, the highest recognition in the gift of The Franklin Institute of the state of Pennsylvania, has recently been awarded to Heike Kamerlingh Onnes and to Thomas Alva Edison. The awards were made on the recommendation of the institute's committee on science and the arts, that to Onnes being in recognition of his "long-continued and indefatigable labors in low-temperature research which has enriched physical science, not only with a great number of new methods and ingenious devices, but also with achievements and discoveries of the first magnitude" and that to Edison in recognition of "the value of numerous basic inventions and discoveries forming the foundation of world-wide industries, signally contributing to the well-being, comfort and pleasure of the human race."

The Franklin Medal Fund, from which this medal is awarded, was founded on January 1, 1914, by Samuel Insull. Awards of the medal are to be made annually to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the institute, have done most to advance a knowledge of physical science or its applications. The present awards are the first to be made.

The medal awarded to Professor Onnes was received on behalf by His Excellency, Chevalier van Rappard, minister from the Royal Netherlands government, at the stated meeting of the institute on the evening of Wednesday, May 19, and at this meeting Mr. Edison was the guest of the institute and received his award in person. Following the presentations, an address entitled "Electricity and Modern Industrial Growth" was delivered by Mr. Insull.

SCIENTIFIC NOTES AND NEWS

DR. FRANK J. GOODNOW was installed as president of the Johns Hopkins University on May 20. After he had delivered his inaugural address on "Modern Educational Ideals," he conferred degrees on twelve distinguished scholars and scientific men who were presented by Dr. William H. Welch. The scientific men on whom the degree of doctor of laws was conferred are as follows: John Mason Clarke, state geologist and paleontologist of New York; John Dewey, professor of philosophy, Columbia University; Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research; George W. Goethals, major general of the United States Army, chief engineer of the Panama Canal; Thomas Hunt Morgan, professor of experimental zoology, Columbia University; Michael I. Pupin, professor of electro-mechanics, Columbia University; Robert Simpson Woodward, president of the Carnegie Institution.

AT its annual meeting held on May 12, the American Academy of Arts and Sciences, acting upon the recommendation of the Rumford Committee, voted: "That the Rumford Premium be awarded by the Academy to Charles Greeley Abbott for his researches on Solar Radiation." The committee has appropriated

$140 to Professor Joel Stebbins, of the University of Illinois, in aid of his research with his improved photo-electric cell photometer upon variable stars.

THE first award of the Ackermann-Teubner memorial prize in mathematics has been made to Professor Felix Klein.

THE British Institution of Civil Engineers has awarded its Telford gold medal to Mr. A. L. Bell (Rosyth); Telford premiums to Mr. C. W. Anderson (Chakradharpur, India), Sir Thomas Mason (Glasgow), Dr. H. F. Parshall (London), and Mr. H. E. Yerbury (Sheffield), and the Crampton prize to Mr. F. D. Evans (Kuala Lumpur).

PROFESSOR SYDNEY J. HICKSON has been elected president of the Manchester Literary and Philosophical Society for the ensuing year (1915–16).

THE corporation and faculty of Brown University gave on May 24 a complimentary dinner to Professor Nathaniel F. Davis and Professor William C. Poland, heads of the departments of mathematics and art, who next month retire on pension, after over forty years of service.

THE Cordilleran Section of the Geological Society of America has elected Professor C. F. Tolman, Jr., of Leland Stanford Jr. University, chairman in place of Dr. H. Foster Bain, resigned, and Mr. Joseph A. Taff, 781 Flood Building, San Francisco, secretary, in place of Professor G. A. Louderback, resigned.

ON the staff of associate editors of the *Transactions of the American Mathematical Society* Professors A. B. Coble and W. A. Hurwitz have succeeded Professors J. I. Hutchinson and Max Mason, who have served since 1902 and 1911, respectively.

H. H. M. BOWMAN, of the University of Pennsylvania, has been appointed botanical research investigator at the laboratory of the Carnegie Institution on the Dry Tortugas. He will sail from New York for the West Indies on May 29.

UNDER the auspices of the American Museum of Natural History, Dr. Robert H. Lowie, of the department of anthropology, will leave early in June in order to undertake investigations among the Hopi of Arizona and the Moapa Paiute of southern Nevada.

DR. F. L. STEVENS, professor of plant pathology in the University of Pennsylvania, will be engaged during the summer in a biological survey of Porto Rico, collecting and studying tropical plant diseases and fungi. He will sail June 5 accompanied by Mrs. Stevens and by several students.

FROM the *Zeitschrift für Angewandte Entomologie* we learn that Dr. Georg Escherich, Forstrat in Isen, was badly wounded by shattering of the tibia near Markirch; Dr. W. Herold, of Greifswald, is in a hospital in Berlin with five wounds; Dr. K. H. C. Jordan, of Neustadt, is in a hospital at Lambrecht; Professor Dr. A. Thienemann, of Münster, has been injured by a shell splinter in the upper thigh and lies wounded at Bonn.

THE Paris Academy of Sciences, after considering a report presented in secret committee by M. Adolphe Carnot, has passed a resolution removing from its membership four German scientific men, including Dr. Wilhelm Waldeyer, professor of anatomy, and Dr. Ernst Fischer, professor of chemistry, in the University of Berlin.

IT is stated in *Nature* that Mr. J. E. Cullum retires from the post of superintendent of the Valencia Observatory, Cahirciveen, Co. Kerry, Ireland, and that Mr. H. G. Dines has been appointed to succeed him, as from May 1. Mr. A. H. R. Goldie has been promoted senior professional assistant to Mr. Dines at the observatory at Eskdalemuir.

PROFESSOR WATERBURY, of the University of Arizona, gave on May 12 an illustrated lecture on "Arizona and the Southwest," before the Civil Engineering Society of the University of Illinois. The pictures shown portrayed the development of the reclamation work in Arizona.

THE final meeting of the year of the Columbia Sigma Xi, at which the Columbia Chapter of the Phi Beta Kappa was the special guest, was held on May 19. Dr. W. J. Gies spoke on "Diseases of the Teeth and Bones, their Causes and Prevention, with Some Demonstrations."

At the second annual meeting of the Kentucky Academy of Sciences, Professor Dayton C. Miller, of the Case School of Applied Science, gave a lecture on "The Science of Musical Sound," and was elected an honorary member of the academy. Professor A. M. Miller, of the department of geology, of the Kentucky State University, has been elected president of the Kentucky Academy of Science.

Dr. Francis G. Benedict addressed the students at Vassar College on Monday afternoon, May 10, on "Investigations in the Nutrition Laboratory of the Carnegie Institution of Washington." In the evening he addressed the advanced students in chemistry and physics and the instructors on "Women as Research Assistants."

Among recent scientific lectures before the faculty and students of Oberlin College have been the following: "Business and Kultur," by Professor Arthur G. Webster, of Clark University; "Some Physical Characteristics of the Vowels," by Dayton C. Miller, of Case School of Applied Science; "Recent Evidences as to the Nature of Molecules and Atoms," by Dr. Robert A. Millikan, of the University of Chicago. Dr. Millikan also made an address on "The Significance of Modern Scholarship," this being before the Society of Phi Beta Kappa.

At the University of Cambridge the Linacre lecture was delivered by Professor E. H. Starling, on May 6, on "The Governor Mechanism of the Heart." The Rede lecture was delivered by Dr. Norman Moore, on the same day, on "St. Bartholomew's Hospital in Peace and War."

We learn from *Nature* that a monument to the late Professor J. H. van't Hoff was unveiled at Rotterdam on April 17. It consists of a bronze statue, double life-size, in sitting position, and has been placed in front of the school at which Professor van't Hoff was educated. The monument is about 30 ft. high, and the statue itself is flanked by female figures representing "Imagination" and "Reason." On the front of the base is the following inscription:

Van't Hoff,
1852–1911.
Physicam chemiae adiunxit.

Joseph Johnston Hardy, professor of mathematics and astronomy at Lafayette College, died at his home on May 2. He was born in New Castle, England, in 1844, and came to this country in 1846. He was graduated from Lafayette College in 1870 and immediately became a member of the teaching staff. He is survived by two daughters and a son, James Graham Hardy, now professor of mathematics at Williams College.

William James Sell, F.R.S., university lecturer and senior demonstrator in chemistry at the University of Cambridge, has died at the age of sixty-eight years.

Erasmus Darwin, the only son of Mr. and Mrs. Horace Darwin, of Cambridge, a grandson of Charles Darwin and of the first Lord Farrer, was killed on April 24 in Flanders. For a time he carried out work in the testroom of the Cambridge Scientific Instrument Company and later became engaged in administrative work.

The April number of the *Review of Applied Entomology* states that Duncan H. Gotch, entomological assistant in the Imperial Bureau of Entomology, London, was killed in action at Nieuve Chapelle on March 11, while acting as second Lieutenant in the Worcestershire regiment.

Mr. Sanderson Smith, malacologist, of Port Richmond, Staten Island, N. Y., died on March 28, aged 83 years. He was born in London on May 14, 1832. He studied in the School of Mines, in London. From 1860 to 1870 he published a number of papers in the *Annals* of Lyceum of Natural History of New York, on the Mollusca of Long Island, Staten Island and adjacent islands. From 1875 to 1887 he was one of the volunteer assistants engaged in the various dredging expeditions carried on by the U. S. Fish Commission off our eastern coast, including the deep sea work, and was of great service in that work. Later in life he made extensive collections of maps, charts and engravings. He also compiled, for

the Fish Commission Reports, lists of all the dredging stations occupied by the vessels of the United States and foreign countries, with all the physical data obtained, thus forming a valuable oceanographic work.

A TELEGRAM received at the Harvard College Observatory from Professor E. B. Frost, director of Yerkes Observatory, Williams Bay, Wisconsin, states that two companion bodies have been found by Professor Barnard near Mellish's Comet. One of these was conspicuous, and had a distance of 28″ and a position angle of 285°, on May 12, at 19^h 36^m. The other was faint, and occupied an intermediate position in the same line. A cablegram received at the observatory from Professor Elis Strömgren, director of the University Observatory, Copenhagen, Denmark, states that Delavan's Comet, the discovery of which was recently announced, proves to be Tempel's periodic comet. Ephemerides of this comet, by Strömgren and Braae, are published in *Astronomische Nachrichten,* No. 4792.

DR. WINFORD H. SMITH, superintendent of the Johns Hopkins Hospital, has announced a gift of $16,500, to be paid in three yearly installments, from Mr. John D. Rockefeller, Jr., to be used in a special social hygiene department at the hospital, which is to be established next September. The work of the new clinic will be in charge of a committee consisting of Dr. George H. Walker, chairman, Dr. Theodore C. Janeway and Dr. Winford H. Smith. Dr. Albert Keiden, a graduate of the Johns Hopkins Medical School, will be the physician in charge of the new dispensary. He will have four assistants.

ON account of the unfavorable state of the finances of the country, due mostly to the European war, the Peruvian government has ordered the closing of the Museum of the National History and Archeology at Lima. This action is much to be regretted, for the archeological part of the museum was, in many respects, the most important in South America.

THE annual meeting of the German Surgical Association was supposedly postponed on account of the war, but we learn from the *Journal* of the American Medical Association that the surgeon-general of the army sent out a summons for the meeting to be held at Brussels. Hundreds of surgeons attended the meeting, which commenced at Brussels on April 7. All the sessions were devoted to military surgery and a number of new points learned from practical experience were brought out. Drs. Garré, Körte, Payr and Bier delivered the leading addresses.

THE fortieth annual meeting of the American Academy of Medicine will be held in San Francisco, June 25 to 28, under the presidency of Dr. John L. Heffron, of Syracuse, N. Y. The sessions will be held in the Auditorium Hall of the Panama-Pacific Exposition. The program will include addresses by the president, Dr. Woods Hutchinson, and Dr. David Starr Jordan. Dr. Jordan's address will be on the Relation of Medicine to the Peace Movement.

THE glass used in this country for the manufacture of lenses is practically all imported except in the case of some of the smaller and cheaper lenses. For several years past, the Bureau of Standards, of the Department of Commerce, has been endeavoring to persuade the glass manufacturers of the United States to take up the manufacture of this material, but they have been unable to do so, partly because of the limited quantity used as compared with other glass, but largely on account of the varying composition required and the difficulty of annealing the glass, as good optical glass must be entirely free from strain. With a view to working out some of the underlying problems sufficiently to enable manufacturers to start in this matter, the Bureau secured two years ago an expert interested in the composition and testing of optical systems, and a little later secured another man skilled in the working of glass to the definite forms required by the theory. These steps were taken first, partly because it is exceedingly difficult to find men having these qualifications, put principally because as the work of experimental glass making progresses, the glass must be put in the form of lenses and prisms to test; in other words, the

Bureau had to be in a position to examine the product as it was made experimentally. In July, 1914, a practical glassmaker was added to the force of the bureau. He is a college graduate of scientific training but skilled in the manipulation of furnaces, and is the sort of a man to make progress at the present stage of the work. Small furnaces were built and melts of a few pounds of ordinary glass were made in order to become more familiar with the technical side. A larger furnace has just been completed which will handle melts of 25 to 50 pounds. The bureau is now making simple glasses according to definite formulas, studying the methods of securing it free from bubbles, and other practical points. This is to be followed by an investigation of the method of annealing. Several glass manufacturers have visited the bureau already for suggestions as to the equipment for the manufacture of optical glass.

IN connection with the election of a new president it is stated editorially in the *British Medical Journal* that the Royal College of Physicians of London has had ninety-seven presidents since Henry VIII., in the tenth year of his reign, granted a charter of incorporation. In granting this charter he said that his main reason was to check men who professed physic rather from avarice than in good faith, to the damage of credulous people; accordingly, after the example of other nations, he had determined to found a college of the learned men who practised physic in London, in the hope that ignorant and rash practitioners might be restrained or punished. The charter was granted to John Chamber, Thomas Linacre, Wolsey, Archbishop of York, and others. The college so constituted first exercised its privilege of electing a president by choosing Thomas Linacre for that office in 1518. Down to 1876, when Sir George Burrows ceased to be president and was succeeded by Sir James Risdon Bennett, a graduate of Edinburgh, the president had always been a graduate of Cambridge or Oxford. Since the spell was broken the presidents have all been graduates of the University of London, with the exception of Sir Andrew Clark, who was a graduate of Aberdeen, and Sir William Church, who is a graduate of Oxford. The new president, Sir Frederick Taylor, elected March 29, the day after Palm Sunday, according to the statutes, is a graduate of London, having taken the degree of M.D. in 1870. He became a fellow of the college in 1879, was an examiner at various periods from 1885 to 1896, was on the council from 1897 to 1899, and was censor in 1904, 1905 and 1910. He has been the representative of the college on the senate of the University of London since 1907. He gave the Lumleian lectures in 1904 on "Some Disorders of the Spleen," and was Harveian orator in 1907. He is physician to Guy's Hospital; his predecessor, Sir Thomas Barlow, was physician to University College Hospital. Sir Richard Douglas Powell, who was president from 1905 to 1910, was physician to the Middlesex Hospital; his predecessor, Sir William Church, was physician to St. Bartholomew's Hospital; Sir Samuel Wilks, who preceded him, was physician to Guy's Hospital. Sir J. Russell Reynolds, who was president from 1893 to a few months before his death in 1896, was physician to University College Hospital; Sir Andrew Clark, who preceded him, was physician to the London Hospital; and his predecessor, Sir William Jenner, was physician to University College Hospital. At the present time the treasurer, the Harveian librarian and the registrar are members of the staff of St. Bartholomew's Hospital. The longest tenure of the office of president was that of Sir Henry Halford, who was president from 1820 to 1844. The office is an annual one, but is, as a rule, held for five years.

THE proposed expedition to Paris of the University of Pennsylvania unit of physicians and nurses who will devote July, August and September to work in the American Ambulance Hospital, will sail early in June for France. Headed by Dr. J. William White, the party will be made up as follows: Surgeon, Dr. James P. Hutchinson; neurologist, Dr. Samuel J. McCarthy; assistant surgeons, Dr. Edmund P. Piper, Dr. Walter S. Lee, Dr. Arthur G. Billings and Dr. Peter McC. Keating; bacteriologist, Dr. Samuel Goldschmidt Gir-

vin, fellow in research medicine, University of Pennsylvania; nurses, Mrs. M. E. Spry, long chief clinic nurse of University Hospital; Miss Jackson and Miss Wagner; anesthetist, Miss Frazer. Explaining the undertaking and its purpose, Dr. White said: "In the early winter the executive committee of the American Ambulance Hospital decided, in the interests of medical science and teaching, and for the purpose of increasing the efficiency of the hospital in the case of large numbers of wounded, to invite certain American universities to send staffs from their respective medical schools to take charge of a floor of 150 beds for periods of three months each. The Western Reserve University took the term of January, February and March; Harvard, April, May and June, and is now on duty. Pennsylvania accepted for the earliest period she could obtain, viz., July, August and September. The other institutions invited were Johns Hopkins and the University of Chicago, which are expected to follow in the order named.

UNIVERSITY AND EDUCATIONAL NEWS

The Circuit Court of St. Louis has confirmed the will of James Campbell, who left his entire estate to St. Louis University School of Medicine subject to a life tenure of his wife and daughter. His estate is valued at from six to ten million dollars.

The late Ward N. Hunt, of Needham, Mass., has made Dartmouth College residuary legatee for $20,000, to establish scholarship funds to be known as the Hunt scholarships.

It is stated in *Nature* that the Hutchinson Museum has been acquired by the Medical School of the Johns Hopkins University. The collection comprises original colored drawings; colored plates taken from atlases, books and memoirs; engravings, woodcuts, photographs and pencil sketches, in some cases with the letterpress or manuscript notes attached. The collection illustrates the whole range of medicine and surgery, but particularly syphilis and skin diseases.

Sir Joseph Jonas has given the University of Sheffield £5,000 to found a laboratory in connection with the applied science department, for testing metals and minerals, especially those involved in the production of steel.

Dr. Henry Suzallo, professor of the philosophy of education in Teachers College, Columbia University, has been elected president of the University of Washington.

Dr. Hermon C. Bumpus, formerly professor of zoology of Brown University and director of the Museum of Natural History, will be installed as president of Tufts College on June 12.

At the University of Oklahoma, Professor F. C. Kent has resigned, and Dr. H. C. Gossard has been appointed instructor in mathematics.

Dr. Moyer S. Fleisher, who has been assistant in the department of pathology of the St. Louis Barnard Free Skin and Cancer Hospital, has been made assistant professor of bacteriology in the St. Louis University School of Medicine.

Dr. Samuel H. Horwitz has been appointed instructor in research medicine in the Hooper Foundation for Medical Research of the University of California, San Francisco.

DISCUSSION AND CORRESPONDENCE

ZOOLOGISTS, TEACHERS AND WILD LIFE CONSERVATION

To the Editor of Science: In spite of the fact that we are familiar with the idea of historic cycles, it is a constant surprise, in watching advances in thought and action, to see that they are usually made not only without the cooperation, but often even with the opposition of those vitally concerned. This is true not only of the prophets of national defense, but is equally so of the protection and conservation of wild life. Strange as it may seem, the most experienced and best informed leader of this movement in this country states that the very people from whom every one should naturally expect the heartiest support—the professional zoologists and teachers of zoology—have been practically a negligible quantity in this defensive and constructive movement. Why is this true? There appears to be some fundamental weakness in this position. Can a factor in the problem be that we have become so engrossed in important

laboratory activity and in domestic animals that there is little interest and concern about wild life? Professor W. K. Brooks once said:

Is not the biological laboratory which leaves out the ocean and the mountains and meadows a monstrous absurdity? Was not the greatest scientific generalization of your times reached independently by two men who were eminent in their familiarity with living things in their homes?

Certainly Hornaday's "Wild Life Conservation in Theory and Practise" (1914) is a volume which should be read by every student of zoology and by all interested in general conservation problems. It is the outcome of a course of lectures given to the students of forestry at Yale, and is clearly an effort to enlist the interest and intelligent support of a *younger* generation of men, as it is on them that the hope for future progress largely depends. Hornaday clearly and forcibly shows the strenuous efforts which have been made in protecting our wild life from the plume hunters and the ordinary ignorant and selfish hunters of all kinds.

To bring out the sound rational foundation upon which protection is based, the economic value of birds is presented to show how they reduce the excessive numbers of insects in fields, orchards and forests, and the aid which hawks and owls give in helping keep down the number of vermin. The proper use of game is shown to be capable of producing millions of dollars worth of valuable food, as well as furnishing recreation for many people. Some of the New England states have already begun to profit by this on a large scale. In his enthusiasm for the cause of protection Hornaday does not go to the extreme and ignore the harm done by certain kinds of animals, or even occasional harm by kinds usually neutral or beneficial. The whole discussion is eminently sane and judicious.

Hornaday makes a strong appeal to the citizen not to allow a few people, a special class, who are reckless in the destruction of animals, and who really care nothing for their obligations to future generations, to advance unhindered in their devastation of our valuable fauna, which, if once lost, can never be restored. He says:

Seventy-five per cent. of the men who shoot game in America, in Europe, Asia and Africa are thoroughly sordid, selfish and merciless, both toward the game and toward posterity. As a rule, nothing can induce any of them to make any voluntary sacrifices for the preservation cause. They stop for nothing, save the law.

Such a view will appear strange and extreme to many, but at the same time it is, to some degree, a measure of one's familiarity with this aggressive campaign. And what will zoologists think of this statement?

And think, also, what it would mean if even one half the men and women who earn their daily bread in the field of zoology and nature-study should elect to make this cause their own! And yet, I tell you that in spite of an appeal for help, dating as far back as 1898, fully 90 per cent. of the zoologists of America stick closely to their desk-work, soaring after the infinite and driving after the unfathomable, but never spending a dollar or lifting an active finger on the firing-line in defense of wild life. I have talked to these men until I am tired; and the most of them seem to be hopelessly sodden and apathetic.

While this is equally true of educators at large, the fact is they are *far* less to blame for present conditions than are many American zoologists. The latter have upon them obligations such as no man can escape without being shamefully derelict. Fancy an ornithologist studying feather arrangement, or avian osteology, or the distribution of sub-species, while the guns of the game-hogs are roaring all around him and strings of bobolinks are coming into the markets for sale! Yet that is precisely what is happening in many portions of America to-day; and I tell you that if the birds of North America are saved, it will not be by the ornithologists at large. But fortunately there are a few noble exceptions to this ghastly general rule.

This quotation is not given to antagonize zoologists, but in the hope that some of their lethargy will be thrown off. If any one doubts the truth of this statement and resents it he is just the sort of person who should read this book. To the open-minded individual who has given no attention to this subject this book will be a revelation. The last chapter is replete with valuable practical suggestions for future constructive protective work. Repeatedly in this book important plans for the

future are outlined, such as the *conversion of our national forests into game preserves.* It is encouraging to know that there are already three endowments devoted to animal protection, one of $340,000, a second for $51,000 and a third of $5,000. Of course these funds should be greatly increased as the period of relatively easy conquest is now over and the opposition is organized with powerful financial support. This contest is a permanent obligation.

The two concluding chapters of the volume are contributed by F. C. Wolcott. One is a valuable summary of the present status of private game preserves, and the other is a very useful bibliography on preserves, protection and the propagation of game.

With this volume and Hornaday's "Our Vanishing Wild Life" (1913) any intelligent person can become informed upon the present status of this phase of conservation.

Chas. C. Adams

New York State College of Forestry,
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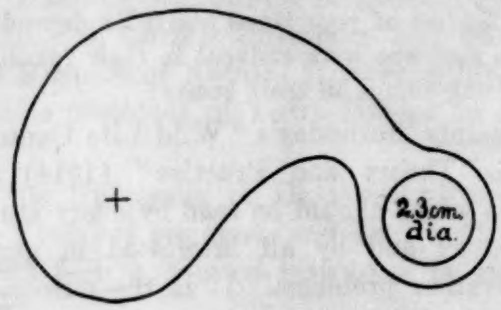
AN EYE SCREEN FOR USE WITH THE MICROSCOPE

Most beginners, as well as many practised observers, usually close one eye when using the microscope. This practise of "squinting" when one is using the microscope for any length of time causes a decided eyestrain. The other alternative of keeping both eyes open requires first of all considerable practise, and if it does not tend to strain the muscles of the eyes, it does give rise to a mental strain, if it may be so expressed; *i. e.,* one has to concentrate his attention constantly on what is seen with the one eye through the microscope, otherwise the objects seen with the other eye will prove very distracting.

The writer, after having tried many different shapes and kinds of eye screens, has worked out one that seems to be the most efficient. It does away with the eyestrain of both types described above, and is very simple and inexpensive.

The accompanying sketch shows the outline of the screen. The material from which it is made is a composition called "vulcanized fiber board," 1.5 mm. in thickness and black in color. This composition board is very tough and durable. It may be obtained from the Diamond State Fiber Company, Ellesmere, N. J. The screen is cut from this board with a knife or with heavy shears. A hole 2.3 mm.



in diameter (a hair larger than the outside diameter of the standard eyepiece) is bored by means of an extension bit at one end of the screen. The distance from the center of this hole to the middle point of the broad wing of the screen is 8 cm. The extreme length and width of the screen is 12.5 cm. by 7.5 cm.

If the composition board is not available, aluminum 1 mm. thick, painted black or dark green on both sides, will be found a good substitute.

The eyepiece of the microscope is slipped through the hole in the screen. The sketch shows the eye screen in position for use with the right eye, and to change to the left eye it is a matter of only a few seconds to take the screen from the eyepiece and invert it.

It will be found that the black surface of the screen is very restful to the eye not in use, and when one alternately uses the right and left eye, it is possible to use the microscope for a much longer period before the eyes become tired than without the eye screen.

Orton L. Clark

Mass. Agr. Experiment Station,
Amherst, Mass.

EXHIBITION OF THE ROYAL PHOTOGRAPHIC SOCIETY

To the Editor of Science: The Royal Photographic Society of Great Britain is holding its sixtieth annual exhibition in August and September of this year. This is the most representative exhibition of photographic work

in the world, and the section sent by American scientific men last year sufficiently demonstrated the place held by this country in applied photography. It is very desirable that American scientific photography should be equally well represented in 1915, and, in order to enable this to be done with as little difficulty as possible, I have again arranged to collect and forward American work intended for the scientific section.

This work should consist of prints showing the use of photography for scientific purposes and its application to spectroscopy, astronomy, radiography, biology, etc. Photographs should reach me not later than Thursday, July 1. They should be mounted but not framed.

I should be glad if any worker who is able to send photographs will communicate with me as soon as possible so that I might arrange for the receiving and entry of the exhibit.

C. E. K. Mees

Research Laboratory,
Kodak Park,
Rochester, N. Y.

SCIENTIFIC BOOKS

Report on Gyroscopic Theory. By Sir George Greenhill. Reports and Memoranda, No. 146, Advisory Committee for Aeronautics. London, T. Fisher Unwin, 1914. Pp. iv + 278, with 49 illustrations. Price 10 shillings.

Many people wonder at the expenditure of time and energy given by the mathematician to subjects like the theory of groups and differential equations. Others can not understand why men of the ability of Klein, Perry and Crabtree should lecture upon the theory of the top. Still others fail to see in the studies made by Maxwell of his spinning top in an agate cup, or of Sommerfield and Noether on the gyroscope, anything to justify a student in following in their footsteps. And yet, when we reflect that the spinning top illustrates a group of motions, that its theory involves the differential equation at the very outset, that the earth is merely a moderate-sized top spinning in space, that the solar system is a somewhat larger one, and that many nebulæ are solar systems in formation, the subject assumes a different aspect, even to the man in the street. And when he further reflects that the stabilizing gyroscope, now made in large numbers by Sperry's company, is used on the aeroplanes above the firing lines in the great war, and acts as a literal balance wheel on the super-dreadnoughts of the warring powers and can be bought in the offices of the makers in any of the large capitals of the world, this same man in the street begins to see that the theorist may touch upon the very practical and that the practical man may well afford to look to the man of theory for help in the affairs of the real life of the present day.

It is such popular considerations as these that may well lead the man of dollars to welcome, even if he can not understand, a monumental treatise like this which Sir George Greenhill, with his usual modesty, has called a simple report. To the general man of science the work will mean much more, even if he too shall fail to read 278 large quarto pages devoted chiefly to mathematics. But to students of analytical mechanics, and particularly to those who look for applications of modern mathematics to dynamics, the work will stand as a monument of patient research on the part of a man who works *con amore* and with an extended vision in a field of rapidly increasing importance.

Sir George Greenhill always writes as he talks, and he never talks like the man whom he delights to refer to as "a mere mathematician." As he sits at the head of a work table in his quaint room in Staple Inn—the room in which Dr. Johnson may have written Rasselas—and talks of his labors on the gyroscope, he is a mathematician for about a minute, a man with the zeal of a boy for another minute, a charming raconteur of stories of his master, Maxwell, the minute later, and an appreciative student of his friends Klein and Sommerfield in the next unit of time. And this description characterizes his addresses, his books, his memoirs and his reports—they are all human, the product not merely of the mathematician, not merely of the student of dynamics, not merely of the experimenter in the laboratory, but always of the big-hearted man.

And so it is with this report. It is filled with mathematics in which elliptic functions, long a favorite study of Sir George's, plays an important rôle; but the reader is continually running across such homely illustrations as those a teacher might use in the classroom—the illustrations of bicycle wheels, stepladders, clock hands, reflections in a mirror, plumb lines, balancing on a knife edge, tops, children's hoops, race wheels, motor cars, the motor omnibus, spinning cards through the air, Whitehead torpedoes, the monorail carriage, and the like—just the sort of things that those who have used the problems in the author's calculus have delighted to find for interesting a class.

The report is divided into nine chapters. Chapter I. relates to steady gyroscopic motion, with applications to the problem of the precession of the equinox and to the gyroscope as a stabilizer. Chapter II. continues the applications of the gyroscope, in particular with reference to ships, the Brennan monorail carriage and the Bessemer saloon. Chapter III. relates to the general unsteady motion of the gyroscope, and to the figures resulting therefrom—for example, to the rosette curve described by Klein. Chapter IV. deals with the geometrical representation of the motion of a top, and in particular with the work of Darboux. Chapter V. treats of the algebraic cases of top motion, and in particular of the section problems, a subject continued in Chapter VI. Chapter VII. relates to the spherical pendulum and related topics, Chapter VIII. to such topics as the gyroscope on a whirling arm, and Chapter IX. to the dynamical problems of steady motion and small oscillation.

It is not intended in this brief review to do more than call attention to the general nature of the work. The practical value of the subject has come to be recognized in this war as never before, and it is well that we have in one place the body of theory which students of the subject would otherwise have to search for in many pamphlets, books and periodicals. The report lays no claim to any important discovery, but it may fairly claim to bring together in convenient form the mathematical theory of the gyroscope as far as it has been developed up to the present time.

David Eugene Smith
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Columbia University

Monographs on Biochemistry. Soil Conditions and Plant Growth. By Edward J. Russell, D.Sc. (Lond.), Director of the Rothamsted Experimental Station, Harpenden; with diagrams. New Edition. Longmans, Green and Co., 1915. Pp. 150.

This is the third edition called for within three years of the best book on the soil which has yet been written. A new chapter has been added on "The Relationship between the Microorganic Population of the Soil and the Growth of Plants." A number of minor changes and a few of considerable importance have been made in the original text, usually because of recognition of literature nonexistent when the text was prepared originally. The versatility of Dr. Russell is astonishing and the wealth of his information is prodigious. And yet he has told his story in some 170 pages without an undue crowding. In fact the book has "charm" and is easily read. The professional chemist, physicist and bacteriologist will find it a mine of information most interestingly woven together, but with frequent references to original authorities. And at the same time the layman can get a purview of the complex system involved in plant production in an understandable story.

Not only is the book the best in its field relatively, but it is very good absolutely. But it is not ideal, and probably most of the experts will feel that its accents should be altered and even that some of the statements should not have been made as they are. For instance, the reviewer should prefer to see the relation between moisture content and the measurable physical properties of the soil given more prominence; and the dynamic as contrasted with the static properties of the soil developed more definitely. One is left with a too hazy idea of the colloidal properties of clay and their importance to the soil, and the purely hypothetical calcium bicarbonate is called upon rather frequently to explain things without

the slightest intimation that its claims to existence are any less valid than any other compound. It is stated that the water in the soil is weakly held, when as a matter of fact the film moisture is held by probably enormous stress and the reader is left in confusion as to just what the author means.. It is not the simplest view (page 77) that the mineral particles are coated with a colloidal complex, but that the so-called colloidal properties of the soil are those resulting from the relatively vast surface presented by the "clay" portion of the soil; and it would be more satisfactory to utilize the fact that the solubility of calcium carbonate is increased by increasing the partial pressure due to carbon dioxide than assume the existence of a compound which can not exist at any gas pressures existing in the soil.

But when there is so very much that is admirable it makes one feel ungracious to continue criticisms of details. The book deliberately makes its major appeal to biologists, and the greater part of the text is devoted to the biological properties of the soil. But its most striking feature is the skilful handling of the contrasting views of soil chemists and physicists. While it is probable that others as well as the reviewer will not entirely agree with the author's presentation of recent controversies, every one will undoubtedly recognize the evident intent of fairness and careful effort to summarize correctly. It is very probable that no one could at this time make a better presentation than has Dr. Russell, although we may each hope that some future edition of his book may accord more closely with our several individual views. Fortunately for the development of this branch of applied science, modification of the personal views of most of the prominent workers is commendably frequent and frank. A satisfactory index and a well-selected bibliography are retained in the present edition.

Dr. Russell's monograph is not suited to class-room use of undergraduates in our agricultural colleges, though such undergraduates would undoubtedly profit by reading it. The book will prove a mine of suggestions to the advanced scholar and investigator and should prove an eloquent testimony for the view that the time has now come when our universities can afford to recognize that some agricultural subjects have developed to a point in dignity of effort and scholarship where they might profitably be included in the curriculum beside older and more familiar academic fields. The advances of the last few years in secondary rural education and in the standard of our American agricultural colleges is worthy cause of gratification. But it is almost a disgrace that our principal universities are utterly failing to train and provide leaders and teachers for what must always be our country's chief field of endeavor; and to recognize that the art of agriculture is passing—rapidly passing in the United States—from the avocation of the artisan to the profession of the highly trained specialist. Dr. Russell's book will not be the least of the instruments to bring about the change.

FRANK K. CAMERON

SHARK INTOXICATION[1]

THE flesh of the economically very important Greenland shark (*Somniosus microcephalus*), a shark usually between 6 and 14 feet in length occurring abundantly in the Arctic Ocean and ranging southward to Norway, the Faeroes, Iceland, Cape Cod, Oregon and Japan, has long been known to possess certain poisonous qualities.

It is not known to what extent the poisonous nature of the flesh of this fish is shared by that of other species of sharks, some of which, at least, appear to be quite harmless; but in view of the possibility that in the near future the flesh of some of our more abundant species of selachians may be placed on the market for the purpose of providing a cheap supply of good fresh food, it would seem opportune to call attention to what is known in regard to the undesirable qualities of the flesh of the Greenland shark in order that similar qualities in the flesh of other species, if present, may be immediately detected.

Mr. Ad. S. Jensen, of the zoological museum of the University of Copenhagen, has re-

[1] Published with the permission of the secretary of the Smithsonian Institution.

cently published[2] the following excellent summary of all that is definitely known concerning shark intoxication.

In North Greenland, where the dog plays such a large part as draught animal for the sledge, the shark fishery has the additional importance of providing food for the dogs. In the dried condition especially shark flesh is an excellent dog food; it gives the animals strength to sustain prolonged exertions without being fatigued. In the fresh condition, on the other hand, it is dangerous for the dogs; when they eat a quantity of it they become heavy and subject to giddiness (they are said to be "shark-intoxicated"); on driving a short distance with them they begin to hang their ears, tumble from side to side and at last fall down in cramp convulsions, after which they can not be got to move from the spot; in a couple of minutes the dog may recover, but when it runs again the whole body quivers and the dog has no power to drag; at the same time, especially when the weather is warm, the animal has diarrhea, its feces are "squirted out" as greenish water; sometimes the animal dies of the sickness. At places where shark food is plentiful, however, the dogs accustom themselves to eating a large amount of it without being sick; but if they are driven in the warm sunshine they may be very bad from it. From dried shark flesh the dogs never become "shark-intoxicated," yet they can also become sick from it, as dried shark meat tends to swell out in the stomachs of the dogs; the Greenlanders therefore advise to give the dogs only small rations of dried shark meat and first to cut the meat into long and narrow strips, so that the dogs do not gulp down the whole at once, but can regularly work through it with the teeth.

To explain these phenomena it may be said that the fresh shark flesh contains a compound that acts like alcohol; when the flesh is boiled, the poisonous stuff is removed and the dogs can then eat more of it without suffering than when the meat is fresh. The poisonous substance is probably present everywhere in the body of the shark, also in the cartilage. Rink was of the opinion that the danger of the shark's flesh was due to its containing a large amount of saline fluids, which were totally swallowed down when the flesh was eaten in the frozen condition. To clear up the matter I consulted the veterinary surgeon S. Hjortlund, who lived for a couple of years in North Greenland and there made investigations on the infectious sickness of the dogs; he has kindly sent me the following information.

"These cases of poisoning, which in Greenland always occur after eating fresh, raw meat of the Greenland shark (*Sominosus microcephalus*), both in men and dogs, is without doubt due to a specific poison (a toxin) which occurs in its body. Nothing indicates the correctness of Rink's view, that the poisonous nature of fresh shark meat was due to the large quantity of saline fluids it contained, whilst many things speak against this view.

"Meanwhile, however, the question has not yet been scientifically investigated and all we know about it is exclusively based on empirical observations.

"The clinical symptoms, of which—as mentioned above—tiredness, dullness, uncertain gait, sensory disturbances and a profuse diarrhea are the most in evidence, depend in virulence on the quantity of meat taken, but in dogs can also be intensified in mild weather and with bodily exertion. In men, where the poison causes a similar complex of symptoms, the sense disturbances both objectively and subjectively give the same impression as acute alcohol poisoning. The symptoms of poisoning may last a shorter or longer time, from a couple of hours to a couple of days. They may be very weak, almost unnoticeable, when the animal has only taken a small quantity; on the other hand dogs have several times been known to die under violent symptoms, almost apoplectic in character, a short time after they had eaten large quantities of shark meat.

"Of importance in judging of the nature of the poisonous stuff or stuffs is the fact that the animals can gradually be accustomed to taking larger and larger quantities of it. Obviously antitoxins can be produced in the body of the dog, which counteract the activity of the poison; in other words, the animal can to a certain degree become immune, and this gradually occurs spontaneously at places where the dogs have constantly the opportunity of eating fresh shark meat.

"The poison, however, is soluble in water and can thus be extracted from the meat by thorough washing. How far, on the other hand, it is destroyed by heating to temperatures below 100° is more doubtful. In any case the transformation here must proceed slowly; for according to all reports the meat must be cooked in two to three different waters before one can be certain that it

[2] "The Selachians of Greenland" ("Saertryk af Mindeskrift for Jepetus Steenstrup") pp. 12–14, 1914.

is not poisonous. It is most reasonable to assume that it is resistant to such a temperature.

"The usual method in practise of preparing the shark flesh so that it may gradually lose its poisonous qualities is to cut the meat into thin strips which are hung up to dry in the sun and air; it thus loses its large quantity of water, and gradually its poisonous qualities disappear, so that it becomes a rather good food for the dogs, though it must still be used with caution and preferably mixed with a little blubber.

"Regarding the seat of the poison in the body of the shark we have the most divergent opinions; some assume that it is only in the musculature, others that it is exclusively present in the cartilage and others again that it is chiefly found in the peritoneal and spinal fluids, as it has been found that these fluids produce a severe pain when received in the eye. A proper judgment on these matters, however, will only be obtained by means of a special investigation of the poison, and such at the same time would elucidate its chemical composition, its physiological properties and various biological reactions."

A. H. CLARK

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SPECIAL ARTICLES

THE CROWN-GALL OF ALFALFA

DURING the past two years the writer has been engaged in studies upon the life-history of the organism described by Magnus[1] in 1902 under the name of *Urophlyctis alfalfæ*. It seems best to publish a brief statement of the results so far obtained, pending further studies.

1. The "resting spores" when placed in water cultures develop into sporangia.

2. Within these sporangia are formed motile spores of two sizes; usually one large spore and many small ones are formed in the same sporangium.

3. One or several small spores may become attached to one large one. Only one remains permanently attached. It has not been determined whether or not this attachment is in the nature of a sexual fusion. If so, the large spores and small spores are obviously capable of functioning as sexually differentiated gametes.

4. The motion of the large spore continues after the attachment of the small spore.

5. The small spores, the large spores and the united spores (zygotes?) become amœboid after a period of motility.

6. In the amœboid state, singly or in groups, these bodies may be observed to move on the surface of the host.

7. In infected soil young alfalfa seedlings develop galls in which plasmodia are found.

8. In older galls similar plasmodia are present which ramify through the tissues of the gall. Previous to spore formation the parasite becomes massed in cavities formed by the destruction of the host tissue.

9. The resting spores are formed in these cavities, apparently by division of the parasite into many cells.

10. The content, cytoplasm and nuclei, of the resting spores in the dormant condition, corresponds to that of the plasmodium in the stage immediately preceding spore formation.

The presence of a plasmodium as the vegetative stage of the parasite and the entire absence of a mycelium at any stage suggest that possibly the organism should be removed from the genus *Urophlyctis*.

ORVILLE T. WILSON

UNIVERSITY OF WISCONSIN

[1] Magnus, P., "Ueber in knolligen Wurzelauswuchsen der Luzerne lebende Urophlyctis," *Ber. der Deut. Bot. Gesell.*, 20, 291–96, 1902. One plate.

A PRELIMINARY NOTE ON THE FOOD HABITS AND DISTRIBUTION OF THE TEXAS HORNED LIZARDS

RANDOM examinations of stomach contents, made by various workers during the past forty years, have indicated that *Phrynosoma cornutum*, the Texas horned lizard, is of great economic importance. To determine its status as a valuable animal, an examination of four hundred and eighty-five stomachs has been made. As only a small per cent. of the animals found in the field were captured and killed, several facts—besides the principal one—concerning this animal have been disclosed.

The Texas horned lizard, unlike the other species of the genus, is distinctly not a desert form. Its area of distribution is quite extensive, going northward into Kansas, southward

far into the Mexican table land, and westward into Arizona; but, clearly, the area of its greatest abundance is the north and south strip of Texas known as the Black and Grand prairies. This strip of country includes the cities of Fort Worth, Dallas, Waco, Austin and San Antonio—in fact all of the large cities of the state except Houston and Galveston; and is preeminently the best part from an agricultural standpoint. Within this area, where conditions are at all favorable, the *Phrynosoma* population averages at least thirty to the acre. This is despite the fact that for a number of years these lizards have been captured and sold to visitors from the east.

The life history has not been well worked out, but the newly hatched young begin to appear by the first of August; so that it is safe to say that the ordinary agricultural operations such as spring and fall plowing, do not interfere with the life cycle. The natural enemies are few and unimportant, being mainly road runners and opossums.

The stomachs examined included the following forms: four species of ants; four species of weevils (very few boll weevils); four species of bees (mainly miner bees); eight species of beetles; three species of stink bugs; nymphs of grasshoppers and allied Orthoptera; five species of flies; and a few caterpillars, some of which have not yet been identified. The noxious forms found overwhelmingly outnumbered the useful forms.

Agricultural ants were found in 80 per cent. and stink bugs in 60 per cent. of the stomachs. Neither of these is much subject to the attacks of birds. Obviously this enhances the value of *Phrynosoma*. Incidentally, there was a remarkable consistency or homogeneity in the contents of the individual stomachs. For example, in one case, nearly all of the forms present would be Hymenoptera; in another, nearly all would be Heteroptera, etc. This could mean that individuals acquire a taste for sour food, or fatty food, etc.; or, what is more likely, that the same individual requires from time to time certain special elements in its food.

From the data thus far assembled, it can be safely affirmed that the horned lizards of Texas are of tremendous importance to agriculture in that region; and may, perhaps, play as important a part there as does the common toad in the better watered regions of the United States.

W. M. Winton

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION D—MECHANICAL SCIENCE AND ENGINEERING. II

The Highways of Hawaii: H. K. Bishop.

Before the days of county government, the central government of Honolulu, under the superintendent of public works, improved many highways with first-class water-bound macadam, in many instances with a telford base. Under the county form of government, the county took charge of the maintenance of the roads already built and the construction of all new ones. It is needless to say that this system has proven unsatisfactory and unproductive of good results in general.

In 1910 and 1911, by legislative action, provision was made by the territory, to raise funds by means of a bond issue and to put the work of road improvement under this issue in the hands of a commission, to be known as the Loan Fund Commission. The writer was engaged in September, 1911, by the Hawaii Loan Fund Commission to prepare plans and specifications and to superintend the construction of the belt road improvement on the Island of Hawaii. The belt road, which is the main highway of the island, approximately parallels the coast line at a greater or less distance entirely around the island, a distance of approximately 250 miles.

In the work of improvement on Hawaii, the general plan adopted was to use water-bound macadam with a telford base in the wet sections, and bituminous macadam in the dry sections. It was also planned to give the water-bound macadam a surface application of bituminous material when the macadam had become sufficiently compacted to make such a treatment successful.

The greatest need of Hawaii is some form of territorial aid to the counties similar to that adopted by the majority of the states of the Union. Hawaii is also in need of some form of centrally controlled highway department which will insure the standardization of road work and a

continuity of the policy. The territory is going through practically the same experience that every state in the Union has been through in its road work.

Service Tests on Various Classes of Pavements: H. W. DURHAM.

A solid unyielding foundation is a necessity for all road construction, but type and details are purely a local question. Much unnecessary confusion is caused in road discussion by inability to discriminate between cause and effect and by laying more importance on details of specifications than on the result they obtain.

The only true test is that of service under conditions of actual use. Final selection must be made among a limited number of types and suit a limited number of conditions. Carrying intermediate operations in the problem of selecting road types to extremes of refinement is unnecessary in that the conditions to be satisfied are few, and the final selection must be from among these classes.

Service Tests of Stone Block Pavements in Brooklyn: H. H. SCHMIDT.

About five years ago studies were begun of the various granite pavements in the borough of Brooklyn, with a view to determining, if possible, the causes which created the objectionable features. Observation showed that certain granite blocks polished under traffic, so that they became extremely slippery; some wore down rapidly at the edges, causing the top of the block to become turtle-backed, which made the pavement extremely rough; some blocks were found which disintegrated under traffic, and still others were extremely rough and not well-shaped, owing to the fact that they were made from a granite which had improper cleavage planes. We learned from the service tests of the stones actually subjected to traffic, that the mineralogical composition of the granite, the presence or absence of certain minerals, and the proportions in which they occur, as well as the size of the crystals, all had a direct bearing on its value for paving purposes.

After a conclusion had been reached as to the most desirable granite, a study of the size, dressing and filler was taken up. With the use of a concrete base, the extreme depth of the block was unnecessary, and the depth was therefore reduced from eight to five inches. With modern granite block it is possible to obtain joints averaging from a quarter to three eighths of an inch. The blocks are laid so close together that a considerable area of the blocks touch one another, thus giving stability to the pavement, even without the joint filler. It is unnecessary with the modern granite block pavement to use paving gravel, and the modern practise favors the use of a mixture of tar or asphalt with hot sand, poured into the joints.

Wood Block Pavements: W. P. TAYLOR.

The Value of the Absorption Test on Wood Blocks: GEORGE W. TILLSON.

When municipal engineers were considering the advisability of laying treated wood block pavements some twelve or fourteen years ago, it was uncertain as to just what should be the requirements of the specifications. It was felt that it was necessary to prevent the blocks from decay and also to treat them so that they would be stable under all climatic conditions; that is, they should not absorb so much water as to swell and cause the pavement to bulge, during a wet spell, nor should they shrink too much in dry, hot weather, so that they would become loose.

After careful consideration, it was decided to require an absorption test of the blocks. The test provided that after being dried in a kiln at a temperature of 100° F. for 24 hours, the blocks should not gain in weight more than 3 per cent. during immersion. Pavements were laid under this specification in 1903 and 1904, and on one street with a preservative that did not contain any resin, but was a specially prepared oil. The blocks obtained did, however, conform to the requirements as to weight and absorption. These pavements have been in use 10 and 11 years, without any expansion joint, and have required almost no attention on account of the instability of the blocks. In certain cases where pavements were laid not under the supervision of the city, so that the absorption test was not applied, the pavements did expand to a very considerable extent.

The city of New York is the only municipality of which the writer knows where the absorption test is required, and it is also the only city, in his knowledge, where an expansion joint is not used. The writer firmly believes that with a heavy oil treatment of 20 pounds and a specification requiring an absorption test, as given above, satisfactory results can be obtained without an expansion joint.

Sand Cushion vs. Mortar Bed for Wood Block Pavements: THEODOR S. OXHOLM.

In this country it has been the custom for many years to lay wood block pavement on a concrete base with a cushion of sand or a bed of mortar between the base and the blocks. A sand cushion is intended primarily to smooth out the

roughness and inequalities in the concrete, so that the blocks might rest evenly thereon. Secondly, the yielding surface of the sand permits the roller to press the blocks into it until they present a smooth surface, adjusting the slight inequalities in the depth of the blocks, and thirdly, the sand has a slight resiliency and protects the blocks somewhat from surface wear. The mortar bed performs the same office as the sand as an equalizer of the concrete surface and the surface of the finished pavement, but there the similarity ceases, for, as the mortar gradually sets it forms a hard unyielding bed for the blocks to rest upon, sacrificing resiliency for immobility.

There are two objections in the writer's opinion to the use of a sand cushion. First, when cuts are made for any purpose through the pavement, it frequently happens that weeks and months elapse before repairs are made; during this time, storm water works its way between the blocks and base and disturbs considerable quantities of pavement that will have to be relaid. This is especially noticeable on streets with a considerable grade, and could not occur with a well-set mortar bed. Second, it would seem that even the slight resiliency of the sand cushion would mean the unstable condition of each block with respect to its neighbors, and a consequent lack of support on sides and ends which is of the utmost importance. The one objection to a mortar bed has always been that the mortar has been mixed damp and time must be allowed for it to set hard (three or four days), before traffic could be admitted, whereas wood block pavement on sand cushion can be thrown open for traffic as soon as completed. The writer has overcome this objection by mixing the mortar dry, and allowing it to set as moisture reaches it through the joints which are always of sand. The roller and immediate traffic work the blocks down to their final beds before the mortar sets. Work of this kind has been examined at plumbing cuts and it has been found that the mortar was set up hard, though traffic had been allowed on the new pavement as soon as completed, and the surface was still uniform.

Cement Concrete Pavements: PERCY H. WILSON.

The author states that the basic principle of the modern concrete road goes back to the ancient Roman roads in that the latter involved the use of puzzolana, the cement used by the Romans, while Portland cement is used as a binder in the modern concrete road.

The author emphasizes the following as conspicuous advantages of the concrete road:

Absence of mud and dust.

Roads passable at all seasons.

An even but gritty surface texture which prevents horses and cars from slipping.

A flat crown making every foot of road surface available for traffic.

Extreme durability increasing with age and exposure to the elements.

Imperviousness to frost and heat.

Moderate first cost and minimum maintenance cost.

With the establishment of expansion joints at proper intervals the cracking of concrete road had been practically eliminated, but when cracks do occur they are filled with tar and sand at small expense, this treatment, to all practical purposes and intents, restoring the slab to its monolithic character.

The paper describes structural methods and calls special attention to the importance of using only the best quality of materials, strict observance of specifications and careful workmanship.

Cement Concrete Pavements with Thin Bituminous Surfaces: W. H. LUSTER.

The concrete surface standing exposed to the weather and chance traffic for fourteen days becomes dirty, and before the hot bitumen was applied it was thoroughly cleaned in order to bond the two materials. Cleaning is of the utmost importance, and to that end the concrete was swept first with wire brooms, then with ordinary house brooms and then flushed with water under pressure by means of fire hose, and while the water was flowing was swept in the direction of the flow to the drainage inlets, but even then there remained the cement scum, or laitance, which always forms at the low spots to which it drains, and there hardens; this must be removed, for it is always smooth and no bitumen will adhere to it, and even if it did, it is not a suitable material for road metal, as it is soft and brittle and soon disintegrates under traffic.

The refined tar was applied hot by spraying under pressure from a moving auto truck tank, containing about one thousand gallons. A comparison of area covered with the capacity of the tank showed that the quantity spread was about one gallon to every three square yards. The bitumen was then covered with a coating of fine quartz gravel, the largest size grain being three eighths of an inch in diameter, and spread in the proportion of one cubic yard to one hundred square yards of surface. The street as thus pre-

pared was closed for twenty-four hours, after which traffic was admitted.

This thin bituminous coating acts in four capacities: First, it waterproofs the surface; second, it acts as a carpet and deadens the noise of traffic; third, it affords good foothold for horses, and fourth, it prevents abrasion of the concrete, thus prolonging its life.

Topeka Bituminous Concrete Pavements Constructed with Tar Cement: PHILIP P. SHARPLES.

The Topeka bituminous concrete is shown to be a revival of types of pavements laid with coal-tar cement twenty-five years or more ago.

The vulcanite pavements of Pittsburgh and tar concrete pavements of New England are described and compared with Topeka specifications.

The precautions necessary to secure successful work with the Topeka specification using coal tar cement are given.

Bituminous Pavements with Two or More Layers of Bituminous Concrete: ARTHUR H. BLANCHARD.

In cases where one product of a stone-crushing plant is used for the aggregate of the wearing course of a bituminous concrete pavement and this product is composed of broken stone varying but little in size, let us say from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in., it will be advisable to use two layers of bituminous concrete. If the above product was used for the first layer and was constructed with a compacted thickness of from $1\frac{3}{4}$ to 2 inches, the second layer might properly be composed of broken stone from $\frac{1}{8}$ to $\frac{1}{2}$ in. in size and spread about $\frac{1}{2}$ in. to $\frac{3}{4}$ in. in thickness. After the second layer had been rolled the pavement could be finished with or without a seal coat of bituminous cement and a dressing of uncoated stone chips. This method is suggested in order to secure with the above type of broken-stone product a surface of the wearing course which will be as dense as when a product ranging in size from $\frac{1}{8}$ inch to $1\frac{1}{4}$ inch is used and the pavement finished with a seal coat of bituminous cement and stone chips.

From a historical standpoint it is of value to note that an English bituminous pavement of similar type was described in the *Engineering Record* of July 23, 1898. The fundamental principles involved have been made use of in the many successful bituminous concrete pavements constructed in England during the past fifteen years under the trade names of Tarmac and Quarrite.

Bituminous Macadam Pavements (Penetration Method): FREDERICK STEELE STRONG.

In determining the quantity per square yard of bituminous material to be used in construction of a bituminous macadam pavement there are four paramount functions to be considered: First, the nature and consistency of the bituminous material; second, the quality of the stone; third, the depth and sizes of the course; fourth, the kind of traffic and severity of climatic conditions.

With this data, the following equation has been deduced for the proper amount of binder to be used in cases where the stone is of low crushing and abrasive strength, this classification not to include any stone which is so poor as to be questionable or worthless. Let Y represent the number of gallons to be used per square yard. Let X represent the depth of the top course in inches. Then $Y = 9/10\ X$. For instance, with stone of low test, and depth of stone of 2 in., we determine that the quantity of binder should be approximately 1.8 gals. per square yard; and by using this equation again, it is found that for a depth of 3 in. the amount of bituminous material should be 2.7 gallons per square yard.

This binder is to be applied in two applications, the first to be two thirds the full amount and the second the balance, and the application is made by pressure machine. I believe no top course for a road of this type should be less than 3 in. in depth. The best stone available should be used even if its cost would entail the use of cheaper material in bottom course, but by this I do not depreciate the importance of a foundation, as without this any road is worthless.

Some Ways to Differentiate between Bitumens: GEORGE P. HEMSTREET.

The Present Status of Adhesive and Cohesive Tests of Bituminous Materials: JOHN S. CRANDELL.

During the past year the writer has made a series of tests to determine the binding values of a number of bituminous binders. The first tests were made as follows: Cylindrical briquets 25 mm. high × 25 mm. diameter, composed of stone, sand, filler and binder were molded under a pressure of 500 kilos per square inch, or 750 kilos per square inch, and were then allowed to season. They were then tested in the small Page Impact Machine that is used for the cementation test of stone. The number of blows required to break or crush each briquet was recorded. Different percentages of the ingredients were tried. It was found that pieces of crushed stone were cracked while in the molding machine. Other mechanical

difficulties developed, and it was decided to increase the size of the briquets to 35 mm. high × 50 mm. diameter. No difficulty is now found in molding the specimens.

These tests, which the writer has called binding value tests, furnish (*a*) an easy means of comparing the adhesive and the cohesive strength of binders, (*b*) a control of the amount of binder to use, and (*c*) a quick way of determining the correct amounts of stone, sand and filler to use.

The Purchase of Asphalt and Asphaltic Cement on the Bitumen Basis: W. H. BROADHURST.

To those familiar with the nature and composition of asphalts and asphaltic cements, the advantages from an economic standpoint of purchasing these materials on the bitumen basis is obvious. The bitumen, or carbon-bisulphide-soluble content of an asphalt, being the cementitious material which binds the mineral aggregate of an asphalt pavement or bituminous concrete together in a compact mass, it follows that, without giving consideration to the character of the insoluble material, or whether the same improves the value of the asphalt as a paving material or is deleterious, the greater the percentage of the insoluble material, the less the efficiency of the asphalt in respect of the number of square yards of roadway per ton of asphalt a given asphalt or asphaltic cement will lay. Hence to place all asphalts in competition on an economically sound or even basis, the same should be bought on the basis of the contained bitumen. Specifications for the purchase of asphalt should therefore be drawn outlining the requirements, first as to quality, and secondly, as to quantity of contained bitumen, instead of requesting merely bids for refined asphalt, or asphaltic cement, which is a very prevalent custom to-day with many municipalities operating municipal asphalt repair plants and state highway commissions purchasing asphaltic cement for state roads.

A Change in the Asphalt Pavement Specification: JOHN MARTIN.

Allowable Maximum Penetration of Various Types of Asphalts for Use in the Several Kinds of Bituminous Pavements: H. B. PULLAR.

The writer would state that in his own opinion there is no set rule which can be adopted or followed in setting a maximum penetration for any type of asphalt or any type of bituminous construction; that it is necessary to consider the local conditions in conjunction with the various bituminous materials on the market and to incorporate them in such a way into the specifications so as to get most satisfactory results. The writer further believes that the maximum penetration is merely one of the many small but important details of construction which must be considered separately for each different piece of work, and that in order to get bids on bituminous materials specifications should be so drawn with limits sufficiently open to produce maximum competition with reverting specifications on bituminous materials, these reverting specifications to be drawn up with limits narrow enough to exclude anything but the highest quality of material for that particular type of bituminous material and at the same time not be unjust to the producers of the different kinds of bituminous materials. Under this kind of a specification it is possible to take into consideration all of the local conditions, the different characteristics, and the inherent qualities of the different bituminous materials and to incorporate in these specifications the allowable maximum penetration for the particular type of pavement and under the particular conditions it is to be constructed, and the writer believes that it is only by this method that the most successful results can be obtained.

A Review of the Use of Bituminous Materials in Highway Engineering during 1914: ARTHUR H. BLANCHARD.

During 1914 the following noteworthy developments have been noted:

In specifications for bituminous materials there has been a tendency to adopt a group of type specifications in place of a blanket specification. By this method engineers have been able to secure the most suitable grade of a given type of bituminous material for a given method of construction, as it is practicable to specify desirable limits for each type rather than have wide limits, as is necessary in blanket specifications. Another self-evident advantage is that more uniform material may be secured by this method.

Bituminous surfaces have been constructed (*a*) with more attention to the physical properties of the road metal composing the wearing course and the requisite dryness and cleanliness of the surface prior to application of the bituminous material; (*b*) using to a greater extent bituminous materials which do not require from several days to three weeks to set up; (*c*) generally employing pressure distributors in place of hand methods and gravity distributors.

In the construction of bituminous macadam pavements there has been a noteworthy tendency to (*a*) use bituminous cements of a lower penetra-

tion than formerly and (*b*) more thoroughly roll the wearing course prior to the first application of bituminous material.

Bituminous concrete pavements have increased in popularity in many sections of America. There has been a general tendency to use carefully heated aggregates and employ mechanical mixers. Bituminous materials of lower penetration than formerly are used in bituminous concrete, the aggregate of which is composed of one product of a stone-crushing plant, the sizes of stone ranging from ¼ in. to 1¼ in. The largest contract for this type of construction during 1914 was the Ashokan Highway, 37 miles in length, built by the board of water supply of New York City.

The third session was held on the morning of Thursday, December 31, Vice-president Dr. Frederick W. Taylor and Mr. O. P. Hood in the chair, with an attendance of about 70. The program of the session was as follows:

Vice-presidential Address: *Safety Engineering:* O. P. HOOD.

Engineering and Industrial Regulations for Promoting Safety in Industrial Establishments: JOHN PRICE JACKSON.

Recent Developments in Precise Leveling: WILLIAM BOWIE.

There should be in each city and state and throughout the whole country connected systems of leveling to form the basis and give the datum for the ordinary spirit or wye leveling.

The nation has, at present, about 31,000 miles of precise leveling with more than 13,000 substantial bench marks. The elevations in the precise level net are referred to mean sea level. The mean surface of the water at the starting points was derived from long series of tidal observations. Mean sea level is the natural and the best datum for a level net. In the first place, it is a fundamental datum, for it can be reproduced; again, with it, leveling can be started at many places with certainty that when the different lines are joined the agreements will be close. Also, leveling by different nations will agree when it is connected on the international frontiers.

There should be only one datum for the whole country, and this is only possible after the level net has been extended to such an extent that no place is far from a precise level bench mark.

The instrument used by the Coast and Geodetic Survey in its precise leveling is generally known as the "United States Coast and Geodetic Survey precise level." Its noteworthy features are that it is made of an alloy of nickel and iron which has a very low coefficient of expansion; its bubble is set down into the telescope near the axis of collimation; and its binocular system, by which the observer can see the bubble, cross wires and rod at the same time. The instrument was designed and made in the Coast and Geodetic Survey Office. It has proved very effective in enabling the observer to avoid or eliminate many of the errors which were in the leveling done with the older types of instruments.

All lines are run at least twice, in opposite directions. To be acceptable the two runnings of a section must agree within four millimeters times the square root of the distance in kilometers.

The average progress in the work per month is now about 86 miles for each party. The maximum progress ever made by one party was in October, 1914, when 148.3 miles were completed. The rapidity with which leveling is now done is due mainly to the use of the motor velocipede cars as the means of transporting the members of the party and to the more efficient organization and management of the leveling parties.

The great accuracy of the leveling is indicated by the probable error of the elevation at St. Paul, Minnesota (the least accurately known place in the net) resulting from the 1912 general adjustment of the level net of the whole United States, which is only $\pm$ 0.065 meter ($\pm$ 0.21 foot). The average correction to the lines forming the net for loop closure is about 0.15 millimeter per kilometer. An investigation of the small systematic and accidental errors in the precise leveling indicates that, when the ground is sloping, more accurate results are obtained on a cloudy afternoon, with a moderate wind blowing, than under the reverse conditions. When the ground is nearly level, the time of the day and the atmospheric and weather conditions do not seem to have any material systematic effect on the line of levels.

The Engineer Out in the World: MARTIN SCHREIBER.

The Teaching of Industrial Economics and Management to Engineering Students: HUGO DIEMER.

Recent engineering curricula show that instruction in industrial economics and management is being introduced in an increasing number of institutions. Examples are cited from the curricula of a number of well-known universities and colleges. Statistics regarding the positions held by the membership of the leading national engineering societies show that more than half of the com-

bined membership of these societies consists of men engaged as executives in manufacturing or contracting work. In such work ability as an inventor is less essential than familiarity with principles and applied methods of industrial management.

The speaker outlines the course in industrial engineering given at the Pennsylvania State College.

This course contains all the fundamental mathematics, underlying science and mechanics given in the standard engineering courses, but in place of the more technical work in designing and testing we introduce work in organization, management, theory of accounts, factory accounting, foundry and pattern-shop methods and organization, machine-shop methods and organization, factory lay-out and design and application of such methods of scientific management as planning departments, including orders of work, bulletining, making of time studies, preparation of introduction cards and tool lists, keeping of cost records and accounts on commercial work actually sold, on the one hand, and certain essential exercise work, on the other hand. The degree obtained by students graduating in this course is that of Bachelor of Science in Industrial Engineering.

Methods and New Apparatus for Measuring the Electrical Conductivity above 1500° C. of Vapors at Normal Pressures: EDWIN F. NORTHRUP.

The electrical conduction of gases and vapors at atmospheric pressure at temperatures above 1200° C. have apparently been little investigated quantitatively. If the investigation is to extend to metallic vapors means must be provided for producing and measuring very high temperatures, and if high pressure can be combined with high temperature, a searching experimental method will be provided of ascertaining the true nature of metallic conduction. Some progress is reported in providing the necessary outfit for the investigation of gaseous and vapor conduction at atmospheric pressure and at temperatures up to the melting point of platinum.

A furnace is described which gives safely a temperature above the melting point of platinum and which will maintain a temperature above the melting point of nickel for at least 140 hours. The furnace can then have its life renewed by the introduction of a new heater-unit. A container for the hot gases or metallic vapors is described.

It is shown that the conduction is considerable but complicated in character. It depends (1) upon the form of the container, (2) probably, upon the material of the container, (3) upon the applied voltage, (4) upon the direction of the applied voltage, (5) upon the temperature, (6) upon the frequency, when an alternating voltage is employed and (7) upon the nature of the gas or vapor.

A description is given of a series of measurements. The data obtained is given, partly in a table and in ten curves.

The considerable conductivity exhibited by a mixture of CO and N above a temperature of 1500° C. suggests the idea that the conductivity found for refractory oxides at and above this temperature is due in considerable part to the hot gases which fill the interstices of the material. This idea was put to the test of experiment and it was found that, under identical conditions in respect to method of measurement, cross section and length of material, etc., at the temperature of 1530° C. through pure aluminum oxide 36 milliampères and through a mixture of CO + N 8.5 milliampères passed, the pressure being 50 volts. Hence it is concluded that approximately 24 per cent. of the conductivity of pure aluminum oxide at this temperature is due to the conductivity of the gases in its pores. It therefore seems safe to make the general statement; *that when the temperature exceeds 1500° C., it is impossible to obtain even approximately good insulation by any means.*

One of the most interesting properties of the conducting power of a very hot gas is the asymmetry of the conduction. In a particular case, at a pressure of 80 volts, 15.5 milliampères passed from a tungsten wire, axially located, to the walls of a graphite cylinder when this wire was made negative, and 45 milliampères when this wire was made positive. The temperature in both cases being 1510° C.

The writer states that high-temperature investigation presents innumerable problems, and it is in his judgment the most fruitful field for chemical and physical inquiry which is at this time presented to chemists and physicists.

Saturated Vapor Refrigerating Cycles: J. E. SIEBEL.

The author analyzes the energy conversion in refrigerating cycles conceived to be operated perfectly reversible by a saturated vapor with negative specific heat (steam as a representative).

Accordingly, it is found that the work required to produce a certain amount of refrigeration in

such a cycle is greater than in a refrigerating cycle operated reversibly by dry vapor of the same medium.

In the latter case the relation between the work W and the produced refrigeration Q is expressible by the equation

$$W = \frac{Q(t - t_0)}{T},$$

while in the former it must be expressed by the formula

$$W = \frac{(Q + Q_1)\ (t - t_0)}{T},$$

Q_1 representing the amount of heat which is to be withdrawn in the compression stage to keep the vapor saturated in a cycle operated between the temperatures t_0 and t, T representing the temperature t in absolute degrees.

The Moment of Inertia in Engineering: D. J. McADAM.

1. Moment of inertia is so important in engineering that its mechanical meaning ought to be well understood and clearly defined.

2. Standard works on mechanics for engineers and mechanics of engineering show that they lose sight of the mechanical effect which it represents and define it and use it as "a name given to a quantity much used by engineers"; and some engineers ridicule radius of gyration as "not being a radius and having nothing to do with gyration."

3. The source of the difficulty in the minds of the users of moment of inertia is: (*a*) Dread of calling inertia a force. (*b*) Failure to see that one of the factors in the square of the arm in the moment is a reducing factor.

4. The ordinary definition of moment of inertia is a secondary statement. It is simply a statement of the result of an algebraic multiplication in form of an algebraic formula; or it is a statement of the method of getting that algebraic formula.

5. The true definition of moment of inertia must define it as the moment of forces just as truly as any other moment of forces. And it must state the unit of force or acceleration in which the forces are expressed.

6. *Definitions.*—(*a*) The moment of inertia of a *particle* with reference to a point is the moment of the force, which acting upon the particle constantly at right angles to the line joining the particle to the point and acting constantly in the same plane, will produce radian acceleration.

(*b*) The moment of inertia of a *beam* at a section is the sum of the moments of the forces which are acting on the various elements of the section when the outer elements are stressed, so that there is unit stress at unit distance from the neutral axis.

7. It is to be observed that in (*a*) the unit force is one producing unit acceleration, and in (*b*) the unit force is unit intensity at unit's distance from the neutral axis. Both are forces, however, expressed in terms of a unit force.

8. In the expression for the moment of inertia of a mass about an axis parallel to the axis through its center of gravity, the term to be added to the moment of inertia of the body about the axis through its center of gravity is the moment of the force which will have to be applied to the mass at its center of gravity to cause it to have radian acceleration. This we find to be $FR = MR^2$.

The Use of Electricity in the Manufacture of Portland Cement: MALCOLM MCLAREN.

Motors were first used in cement manufacture for driving light machinery in the outlying portions of the mill. As the mills increased in size the use of motors became more general, until now in many cases the entire mill is operated by electric power.

A method is given for determining whether, in an existing mill using steam engines for driving the machinery, it would be advisable to adopt electric drive. It is shown that the mill output should be increased by the change, but that the greatest saving in operating costs would be due to the fact that the steam economy of the steam turbines used with electric drive should be much greater than that of the engines they would replace.

Considering the question of whether the cement company should generate its power or purchase this from a supply company, it is shown that the cost of power per unit depends largely on the amount of power developed. A large supply system, therefore, which carries the combined load of many customers, should be able to produce power at a lower rate than could be done by any of the smaller constituent companies.

Various Engineering Problems in Connection with the Hydro-Electric Plant of the Housatonic Power Company at Bulls Bridge, Connecticut: CHARLES RUFUS HARTE.

Latest Developments in Marine Electrical Engineering: H. A. HORNOR.

This paper gives a brief review of progress in the development of marine electrical installations. It emphasizes the importance of electric steering, anchor windlass and other recent requirements. The possibilities of under-water communication are considered and improvements in searchlight projectors recorded. The essential points in connection with the introduction of electric propulsion and the opening field of possibilities not only in the design of efficient electrical apparatus but also in the effect upon the art of naval architecture are concisely stated.

The Nolachuckey Hydro-Electric Plant of the Tennessee Eastern Electric Company: W. V. N. Powelson.

The Location and Maintenance of Railroads and Highways along Steep Slopes: Walter Loring Webb.

The paper describes the development of a new principle of construction, when it is necessary to place the roadbed of a railroad or a highway along a slope which already is so steep that any increase in the rate of the slope, made by forming the side slopes above or below the roadbed, causes frequent slides. The usual practise has been to construct retaining walls on the upper or the lower side of the roadbed (or perhaps on both sides) which are necessarily expensive, since they must always sustain a great weight of earth. The method described utilizes the skeleton construction permissible by reinforced concrete and reduces to a minimum the stresses which must be sustained by the structure. An illustrated example of the application of this principle, as developed by the writer in Oil City, Pa., is given in detail. Another illustration of the same fundamental principle, as recently described in the technical press, is also given.

Construction of the New Double Track Tunnel of the B. & O. R. R. through Alleghany Mountains at Sand Patch, Pennsylvania: Paul Didier.

Reconstruction of Bridge No. 100, Pittsburgh Division: J. C. Bland and John Miller.

This bridge, situated a little west of Coshocton, O., was partially destroyed by flood in March, 1913, and the wrecked spans temporarily replaced by girder spans.

The structure, before the flood, consisted of four double tracks through pin-connected truss spans, each 152 ft. 2 in. c. to c. end pins, and was replaced by three double track, through riveted truss spans, each 240 ft. c. to c. end pins. The total shipped weight of the three spans was 2,740 tons.

The old masonry was replaced by new concrete piers and abutments, the foundations for these being sunk by pneumatic caissons. This new masonry was built by the Foundation Co., of New York.

The new bridge was erected on falsework on the downstream side of the old, and when completed, was used as a run-around to carry traffic while the old structure was being dismantled. The new spans were then rolled into position.

Both the weight moved, 3,250 tons, and the distance moved through, 44 ft. 9 in., constitute a record for an operation of this nature.

The new steelwork was manufactured by the American Bridge Co., of New York, and was erected by the Seaboard Construction Co.

The bridge was designed by Mr. J. C. Bland, engineer of bridges, Penna. Lines West of Pittsburgh, under whose supervision the erection also was carried out.

A Balanced Cantilever Bridge: Henry H. Quimby.

A bridge of a new type was recently constructed at Chester, Pa. It consists of two independently acting parts, each being a double cantilever of ten longitudinal ribs of reinforced concrete resting on a pier over which it is balanced with a counterweight, the channel ends of the cantilevers being connected by a short so-called suspended span, and the whole forming in appearance a concrete arch.

The type was devised as the most economical method of securing an ornamental arch bridge which was desired at this point by the public authorities for esthetic considerations, the subsurface conditions making a real arch very expensive. These conditions consisted of deep soft mud on one side of the river underlaid with a bed of rock sloping steeply away from the channel to a considerable distance and depth, affording no natural skewback for an arch to thrust against.

The pier on the deep mud side is on wooden pile foundations with concrete capping, lateral stability being obtained by surrounding the pier with spur or batter piles.

The bridge is one hundred and sixty feet long over all, with the main span ninety-five feet centers of piers, and the wings thirty-one and thirty-four feet, respectively. It is sixty feet wide, with cartway thirty-six feet between curbs.

The action of the double cantilever is that of the double overhanging gantry crane, the dead load balanced with equal moments over the middle

of each supporting pier, and the traveling live load shifting the center of combined load forth and back over the middle within a range not exceeding one third of the width of the pier, so that tension is never developed at the edge of the bearing.

An open joint was made at one end of the suspended span to provide for temperature movements as well as to keep the cantilevers independent of each other, but the pressure of the earth fill against the ends of the bridge keeps the joint in contact and makes the bridge a real arch to the extent of that pressure, and giving it, under ordinary loads, all the rigidity of an arch.

The Newark Terminal: Martin Schreiber.

Cooperation between the Physicist and the Engineer: Carl Hering.

Defining engineering as "applied physics," and stating that the province of the physicist is to discover and formulate the laws of nature, while that of the engineer is to then apply these laws and data to the construction of useful structures —the author urges a closer cooperation between them, and shows how much the work of the engineer is dependent upon that of the physicist.

As illustrations of its importance he cites cases in which engineering structures failed due to incomplete statements of the laws of nature in books on physics; or in which in applying the physicist's laws it was found by the engineer that they were faultily stated, resulting in misleading or even wrong results. In other cases the engineer discovered new laws which it was the province of the physicist to have given him, the physicist being better equipped and trained for such research than the engineer.

The physicist taught nothing at all in his books about any internal forces in conductors due to the electric currents flowing through them, yet the engineer in his constructive work found them to exist. Maxwell's famous law of induction, as stated by the physicist, when applied to a specific case gave results which were contrary to the facts, as was found in the constructive work of the engineer. Physics says nothing about axial electromagnetic forces in conductors, yet the engineer finds them to exist. The physicist's work is the foundation of the structure of the engineer, and with an insecure or doubtful foundation, the structure is not dependable. Much time, money and failure can be saved to the engineer if the physicist gives him all the necessary data and states the laws of nature correctly and completely.

Attention is called to cases in which quantitative laws of certain physical phenomenon have not yet been established by the physicist. Overlooking the distinction between the physical and chemical parts of thermo-chemical processes is criticized.

Concerning units for measuring physical quantities, it is shown that the physicist is far ahead of the engineer and the latter would often save himself much work in his calculations by adopting decimal multiples of the absolute units, as was done in the case of the electrical units in which all the conversion factors are made unity by definition. Useless double units should be eliminated, but for some cases double units are advocated for eliminating the factor π from many calculations. In creating new units, physicists are urged to base them on the absolute system, to avoid the use of conversion factors. The physicist's unit of "brightness" of light is criticized as a physical inconsistency and as being an unnecessary double unit.

Numerous references are given to articles in which the topics touched upon are discussed more in detail. The author hopes that his illustrations will show the importance and the benefits of a closer cooperation between the physicist and the engineer.

The fourth session was held on the afternoon of Thursday, December 31, Mr. O. P. Hood in the chair, with an attendance of about 35. The program of the session was as follows:

Some Engineering Achievements in Philadelphia and Environs: Edgar Marburg.

The Hydraulic Laboratory of the Civil Engineering Department, University of Pennsylvania—Its Equipment and Operation: William Easby, Jr.

Some Laboratory Accessories for Materials Testing: H. C. Berry.

Correct Methods of Creating and Maintaining Channels at the Mouths of Fluvial and Tidal Rivers, and at the Outlets of Inclosed Tidal Areas: Elmer Corthell.

The Engineers' Interest in Deep Waterways with Special Reference to Mississippi River and its Tributaries: Harry E. Wagner.

The Tide Water Outlet of the New York State Barge Canals: D. A. Watt.

This paper presents a brief sketch of the work now being constructed by the federal government at Troy, N. Y., in order to provide a connection between tide water in the Hudson River and the

extensive system of state canals, known as the barge canal, now nearing completion by the state of New York. These new canals will provide a modern waterway, not less than 12 feet in depth, between the seaport of New York and the Great Lakes, with a spur running northward along the Hudson Valley to Lake Champlain. The work is practically a reconstruction of the existing system of canals, which have a depth of only 6 feet, but which, nevertheless, constitute an influential factor upon the freight rates of a considerable portion of the United States.

The works which will form the outlet at Troy of this great system will consist of a lock with two tandem chambers, which together will have an effective horizontal area of more than twelve times the area of the present single locks, and the dam will have a length of nearly a quarter of a mile. In addition to these works, between 20 and 30 miles of river channel have to be deepened an average of 3 to 4 feet, so as to provide the channel depth of 12 feet.

The American Bridge Company School Work at Ambridge: J. E. Banks.

Some Features of the Engineering Plant for the New Agricultural School near Farmingdale, New York: Ralph C. Taggart.

The Human Nature Element of Engineering Construction with Particular Application to Tropical Situations: T. Howard Barnes.

The Dome of the Columbia University Library: O. W. Norcross.

The Inspection Department in Its Relation to the Management of Manufacturing Organizations: Fred. B. Corey.

In this paper the author calls attention to the disadvantages inherent in the usual plan of factory organization, in which the inspection department is under control of the works superintendent, and to the great advantages to be gained by placing this department under authority of an executive reporting directly to the general manager, or other officer in control of the factory output.

The executive head of the inspection department should be thoroughly familiar with general engineering practise and standards. He should be well informed in all shop methods, including foundry and machine-shop practise, and be thoroughly versed in the use of testing machines and gages. He should, if possible, be conversant with chemical laboratory methods and apparatus, so as to be able intelligently to direct that part of his organization. Moreover, he should be familiar with the uses of the factory products and the conditions under which it is to operate after it has passed beyond control of the factory. He must have absolute control of every inspector in the plant and be held responsible for the quality of material and workmanship of all that the plant produces.

The relations that should exist between the inspection department and the sales and engineering departments are quite fully outlined. The inspection department, if rightly conducted, acts for the mutual protection of the manufacturer and the customer and can be of great assistance to the sales department in various ways. At the same time it should maintain the closest possible relations to the engineering department and plans are outlined by which practical cooperation may be secured.

Detail methods of inspection must be suited to the special conditions of each case. It is obviously absurd to try to apply big-shop methods to a small shop, and the converse application, while far more usual, is no more logical. Such matters must, therefore, be subjects of careful investigation and study in each individual plant.

The Application of Science to Telephone Engineering: George S. Macomber.

Reinforced Concrete as an Emergency Repair for Iron Chimneys: A. L. Pierce.

Mining Engineering Problems Incident to the Development of the South African Diamond Mines: Gardner F. Williams.

Shaft Sinking in Excessively Hard Rock: William Young Westervelt.

The Refrigerating Plant at the Washington Market, New York City: Charles H. Higgins.

Removal of Henderson Point at the Portsmouth Navy Yard: O. W. Norcross.

New Machine for Ginning and Cleaning Cotton: George T. Burton.

Spiral Wrappings with Special Reference to Flat Spiral Springs and Stresses in Steel: B. Spencer Greenfield.

At the conclusion of the session an inspection of the new engineering laboratories of the University of Pennsylvania was made under the direction of Professors Edgar Marburg, William Easby, Jr. and H. C. Berry.

Arthur H. Blanchard,
Secretary